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SCIENTIFIC AMERICAN SUPPLEMENT. No. 1628

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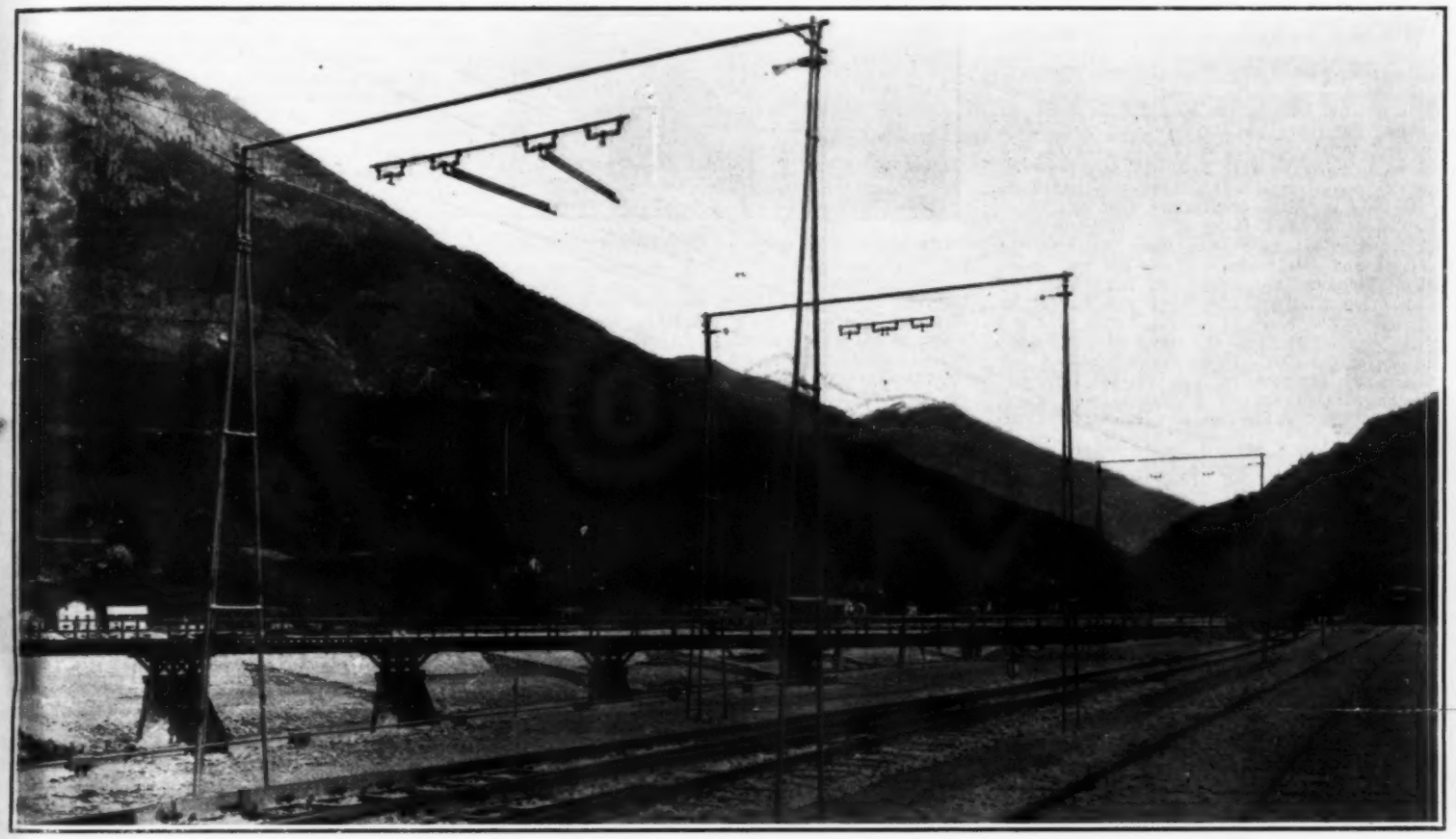
Scientific American, established 1845.
Scientific American Supplement, Vol. LXIII., No. 1628. NEW YORK, MARCH 16, 1907. Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.



THE SYSTEM OF SUSPENDING THE CONDUCTORS AT CROSSINGS, SWITCHES, AND SIDE-TRACKS.

GENERAL VIEW OF THE BRIGUE STATION, SHOWING THE NETWORK OF TRACKS AT THIS POINT.

THE ELECTRIFICATION OF THE SIMPLON TUNNEL RAILWAY.

THE ELECTRIFICATION OF THE SIMPLON TUNNEL RAILROAD.

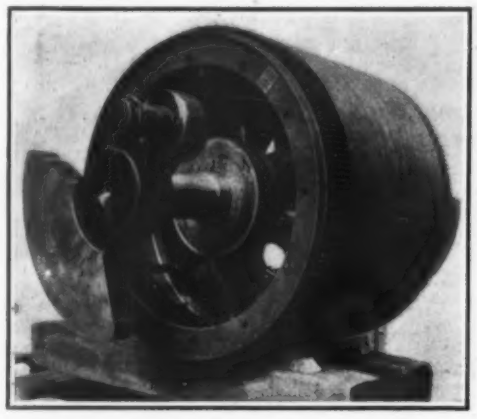
By Our ENGLISH CORRESPONDENT.

ONE of the most important of the recent developments in electric traction in Europe has been the conversion of the railroad through the Simplon Tunnel to this method of operation. The question of adopting electric traction upon this 12½ miles of tunnel road was first proposed in the early days of the enterprise, since it was recognized that this method of traction possesses many advantages over the ordinary steam train operation, the most prominent being the absence of smoke and heat, with the accompanying alleviation of the difficulty concerning the ventilation of the tunnel, which on account of its great length, would with steam operation have constituted a difficult problem. By the time the excavation of the tunnel was completed, the great strides that had meantime attended the application of electricity to trunk railroads rendered the possibility of the system being applied to this tunnel altogether probable.

In the latter part of 1905 Messrs. Brown, Boveri & Co., of Baden, Switzerland, presented a project for carrying out the work to the federal authorities. In this scheme they offered at their own risk to install a system of electric traction within the tunnel, and undertook to have the work finished before the exhibition was opened at Milan; and moreover, they offered to place the whole undertaking upon completion at the disposal of the authorities, for the purposes of comparing upon a large practical scale the respective advantages and disadvantages of electric and steam traction. This offer was accepted by the federal railroad department after a prolonged and careful investigation of the proposed scheme, but it was not until the close of the year that they intimated their acceptance of the offer. This delay left only a few months to the engineers to carry out the task, and the system selected was the three-phase, with which the promoters had had the greatest experience. Furthermore, at that time the firm of Brown, Boveri & Co. were constructing two three-phase locomotives of 1,000 horse-power each for the Valtellina railroad, and in order to save time it was decided to seek permission from the railroad department of the Italian government, for whom they were being erected, to permit them to be temporarily employed upon the Simplon Tunnel, which consent was readily extended.

To save time, it was decided not to establish special power stations, but to resort to the existing resources of power supply wherever possible. The stations which had been utilized for supplying the power and other requirements in the work of boring the tunnel were found to be perfectly suitable for generating the power necessary for the electric traction. The two stations at Brigue and Iselle respectively were requisitioned, and although out of date in comparison with the latest ideas of power stations, were after some alterations rendered available for the new system of operation. In these two stations the current is generated at a pressure of 3,300 volts with a periodicity of 16 cycles per second, which potential was perfectly suitable for direct supply to the motors without recourse to intermediate transformers. Furthermore, it so happened that the Valtellina locomotives which were being constructed were designed for this pressure and frequency. At a later date, however, these two power stations will be supplanted by one larger station, but the existing facilities are sufficient to fulfill the object of the present scheme.

The Brigue generating station contains one three-phase alternator rated at 1,200 horse-power at 160 revolutions per minute, but quite capable in emergencies of supplying temporary overloads up to 1,500 horse-power. It is driven from a main transmission shaft, which in turn is driven by two Escher-Wyss turbines of 600 horse-power each, the fall being 146 feet. A 95-horse-power alternator, which formed part of the original plant of this station, is utilized for exciting the alternator. At the time this station was equipped for supplying the requisite power to the boring appliances, the Escher-Wyss turbine was not fitted with an automatic regulator, so that in order to maintain a constant speed it was necessary to use in the



THE ROTOR OF A SIMPLON TUNNEL LOCOMOTIVE MOTOR.

generator circuit a water resistance of such capacity as to be capable of absorbing, when necessary, the whole of the energy given out by the alternator. In order to adjust the capacity of the water resistance in accordance with the load of the line, an automatic regulator is fitted, so that the alternator is always kept fully loaded and there is no danger of any serious variation in speed. There is one switchboard upon which are mounted all the requisite measuring instruments and apparatus for controlling the circuits.

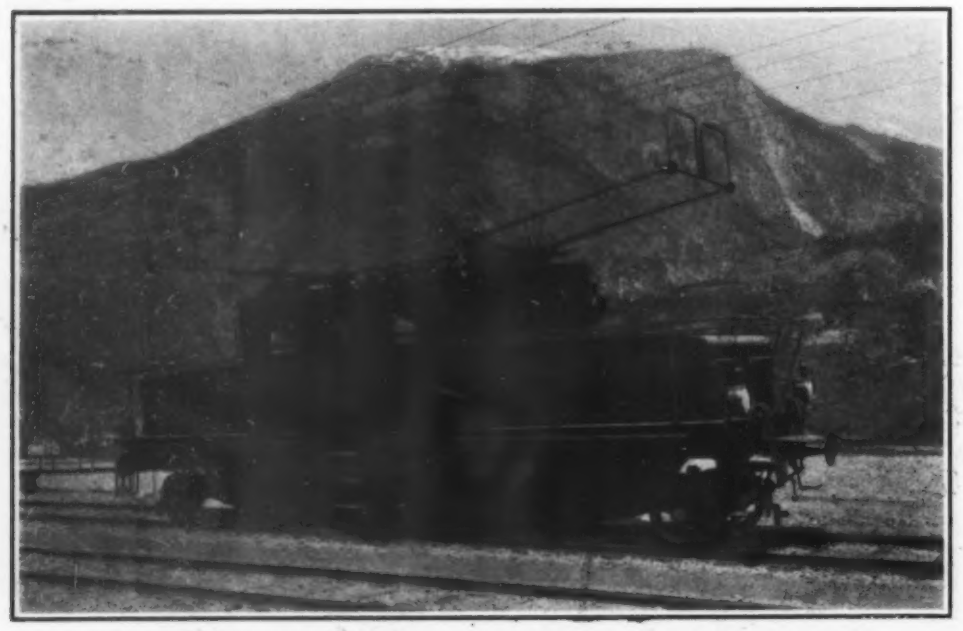
At Iselle the old station utilized for pumping and other operations in connection with the tunneling was pressed into service. The plant here is a trifle more powerful than that at Brigue, the three-phase alternator being normally at 1,500 horse-power, but capable of being temporarily overloaded up to 1,800 horse-power or more. It is coupled direct to a Picard & Pictet double-ended turbine, each of the turbine units being capable of developing 750 horse-power. The set runs at 960 revolutions per minute with a fall of 460 feet, and is fitted with a sensitive governor which maintains the speed fairly constant. The excitation current is taken from a continuous current machine of 95 horse-power at 125 volts. The switchboard and the gear is practically the same as that installed at Brigue.

The stretch of railroad which has been electrified comprises that between the two tunnel stations of Brigue and Iselle respectively.

The road is divided into five sections, as follows:

1. From the Brigue station to the northern entrance of the tunnel.
2. The northern half of the tunnel.
3. The crossover in the middle of the tunnel.
4. The southern half of the tunnel.
5. From the southern end of the tunnel to the Iselle station.

Section switches are provided at Brigue, at Iselle, and at the station at the cross-over in the center of the tunnel, telephonic communication being provided for transmitting orders to the operators in charge of the various switches. The supply is maintained by means of two overhead conductors, the rails being the third conductor. Outside the tunnel the line is suspended on cross wires strained between drawn steel poles which are placed on either side of the track. At curves the poles are arranged in the manner shown in one of the accompanying illustrations, for the purpose of increasing resistance to side strain. Two different methods of supplying each track had to be adopted. At Brigue there is ample distance between the tracks, so that each line is carried upon a separate set of poles, thereby rendering the whole work of construction of a solid and strong description, while at the same time work can be maintained upon one line without affecting those adjacent. At Iselle, however, the various tracks are congested and placed too close to one another to admit of poles being erected between tracks, with the result that it became necessary to adopt much longer spans of cross wires to the two poles on opposite sides of the road, a catenary system of suspension being employed.



THE TYPE OF LOCOMOTIVE USED ON THE ELECTRIC SIMPLON TUNNEL RAILROAD.

The suspension of the conductors within the tunnel itself is carried out upon exceptionally strong lines, so that the possibilities of breakdowns due to failures of suspension are reduced to the minimum. Cross wires span the tunnel, and these are strongly secured to either wall by heavy gun-metal bolts cemented directly into the face of the tunnel. But although great strength has been the dominant factor in the erection of these cross wires, they have at the same time been kept as simple as possible. In order to insure the maximum stiffness without straining, one single wire has been used, and the strain insulators have been dispensed with, as their utilization only tends to weaken the whole suspension. The cross wires, placed at intervals of about 83 feet on the straight sections, and about 42 feet on the curved portions of the line, are simply fixed at either end to a porcelain insulator and so arranged that the wires can be drawn as tight as required. It was found unnecessary to place the cross wires closer together, because the temperature within the tunnel is practically constant, while the conductors can be strained very tightly, so that the sag even in stretches of 80 feet or more is very slight.

The problem of keeping down the pressure drop in the tunnel, which is 12½ miles in length, was one requiring careful consideration, since it was deemed advisable not to employ transformers in the tunnel. The difficulties in this direction were finally overcome by utilizing conductors having a somewhat larger section through the tunnel than those upon the two outside stretches, which are of 0.078 square inch section per pole, the diameter being 0.315 inch, and using two wires per pole each of a similar section in preference to one wire of a larger diameter. This decision was influenced by the fact that the diameter of the 0.315-inch is the largest in general use for overhead contact lines, and there is also a greater possibility of the metal being more homogeneous throughout and harder than with wires of greater diameter; smaller wires, moreover, are far easier to handle than large wires, while the provision of two wires per pole insures far better contact surface on the bow collectors of the locomotives. There is, however, a far greater advantage accruing from the adoption of two conductors, and that is, should one fail or break, the service is not immediately disorganized and the train brought to a standstill in the tunnel, which event would be attended with great inconvenience, since the current can still be derived from the second wire until the pressure can be taken off the line and the faulty conductor repaired. The possibility of the two conductors breaking down simultaneously is very remote.

Double insulation in porcelain and ebonite is used, the insulators being constructed of a piece of ebonite in the form of a bolt, from which the conductor is suspended. This bolt is carried in a cross piece of gun metal fixed at its two ends in strong porcelain insulators by means of hemp and asbestos. The complete insulating block is suspended from the cross wire, the insulators being carried in gun-metal pieces. The engineers have found this system of insulating to be completely efficient and reliable, since no matter if one of the insulators shows signs of being defective, the other will be in every way adequate to prevent leakage until it is possible to repair it. All insulators are subjected to periodic inspection, and each is thoroughly tested with a pressure of 18,000 volts. Each separate insulator, both ebonite and porcelain, is submitted to a test of 10,000 volts, so that the complete insulating block can withstand a pressure ranging from 30,000 to 40,000 volts. This test is far more than is requisite for a working pressure of 3,300 volts, despite the most unfavorable atmospheric conditions. For the purpose of making the wear upon the collecting bows as even as possible, the overhead conductors are not kept parallel to the rails throughout the length of the tunnel, but are staggered from cross wire to cross wire.

It has already been pointed out that the rails themselves constitute the third conductor, and for the bonding of these Messrs. Brown, Boveri & Co. employed their own system, the salient feature of which is that all copper connections between each rail are dispensed with, the ordinary fishplates themselves being utilized to conduct the current from one rail to the next without additional connections of any description. In this patented system it is necessary to clean thoroughly the surfaces of the fishplates and the two ends of the rail which come into contact and are bolted together. For this purpose the engineers devised a special sand-blast apparatus carried in a car driven by gasoline motors, which were also utilized

to drive the blasting apparatus. The surfaces to come into contact are not only well cleaned, but are also rendered perfectly smooth, so as to come tightly together. They are then covered with a patent paste which absolutely prevents any oxidation of the contact surfaces, and at the same time allows a free passage to the current. The fishplates are then bolted up in the usual manner to the rails, and a perfect and permanent connection is thus assured. The advantages of this system are its simplicity, cheapness, and efficiency. The work can be carried out much more quickly than with the ordinary copper bonding, while the severe tests to which it has been submitted upon other systems demonstrate its permanency and its eminently satisfactory nature. The system was also severely tested upon the Brigue section when completed, wherein it was found that the conductivity of the bonds was equal in every respect to that obtainable with homogeneous rails.

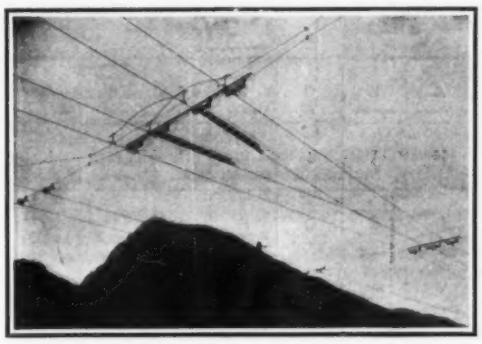
The electric locomotives possess many important features. At the present time they are five in number, three of which were borrowed from the Valtellina railroad until those intended for the actual regular service can be constructed. Progress upon the latter is at present being maintained both at the Baden and the Winterthur locomotive works of Messrs. Brown, Boveri & Co. From the designs of the joint engineers of both establishments has been evolved the class adopted. It is of the bogie type, having three axles, all of which are driven. The traction motors are placed between the three pairs of driving wheels, and both drive on the middle axle by means of a bar coupling them rigidly together. This axle in turn drives the other two by means of a coupling rod, so that gears are dispensed with. The motors are not keyed to the axles, since it was considered that better opportunities for overhauling and repairs would be offered by the coupling system. The principal dimensions of these locomotives are as follows:

Length between buffers	40 ft. 6 in.
Total length between axles	31 ft. 10 in.
Distance between driving axles	16 ft. 1 in.
Distance between bogies	23 ft. 0 in.
Diameter of driving wheels	5 ft. 4½ in.
Diameter of smaller wheels	2 ft. 9½ in.
Weight on driving wheels	42 tons
Weight of mechanical portion of equipment	34 tons
Weight of electrical portion	28 tons
Total weight	62 tons
Normal output of two motors together	900 horse-power
Maximum output of two motors together	2,300 horse-power
Weight of motor complete	10¾ tons
Normal speeds	42 miles per hour 21 miles per hour
Drawbar pull at 42 miles per hour	7,700 pounds normal 20,000 pounds maximum
Drawbar pull at 21 miles per hour	13,500 pounds normal 31,000 pounds maximum

When starting at the higher speed with a passenger train weighing 300 tons, a drawbar pull of 16,600 pounds is required in order to attain the specified acceleration of 0.5 foot per second per second; and when starting at the lower speed with a freight train weighing 400 tons, a drawbar pull of 20,000 pounds is requisite to obtain the specified acceleration of 0.36 foot per second per second.

The traction motors possess one or two distinctive features. They are each rated at 450 horse-power and work with current ranging from 2,700 to 3,000 volts at 16 cycles. Their momentary overload capacity is very high, being as much as 1,150 horse-power per motor at the higher speed of 42 miles per hour. At the lower speed of 21 miles per hour they are rated at 390 horse-power, but can be overloaded continuously up to 575 horse-power. In comparison with the Ganz three-phase system as worked on the Valtellina line for changing speed, the Brown-Boveri principle is distinctly advantageous and simple. Whereas the former employ the cascade method of coupling the motors, the latter have evolved a pole-changing device for changing the speed. This device is worked out as follows: The stator or winding is provided with six terminals connected first either in mesh, the six windings of the motor providing only three circuits forming sixteen poles and running at 112 revolutions per minute; or secondly, in star forming eight poles and running at 224 revolutions per minute, which corresponds to a speed of 42 miles per hour. The rotor has a six-phase winding comprising two groups of three each, and so arranged that when the number of poles is changed on the stator, no modification whatever is required on the rotor. One noticeable advantage accruing from this system is that the maximum of output is possible with the minimum of weight, there being a saving of 2½ tons in the weight of the motors, which are the lightest that have ever been constructed up to the present, since they develop a maximum output of 1,150 horse-power and only weigh 10¾ tons including the coupling rods. The motors are well protected against damp and air saturated with moisture, which is constantly encountered in the tunnel.

The current is collected from the overhead wires by means of two bow collectors mounted fore and aft and about 27 feet apart on the roof of the locomotive. They are made in two parts, the lower section being a hinged frame, while the upper is the collector proper. This latter is also pivoted at the upper end of the frame, and arranged in such a manner that on the normal track where the height of the suspension wire is 19 feet it can oscillate freely without displacing the main framework. In the tunnel itself, as the height of the overhead conductor is two feet less, being only 17 feet, the frame is lowered right down. The collectors are operated by compressed air in lowering and raising, while they are also kept in contact with the line by the same means. There is a compressed-air piston operated from a valve, which extends or releases a spring so as to raise or lower the bows. When the locomotive has been standing and



THE METHOD OF SUSPENDING THE CONDUCTORS AT A SWITCH CROSSING.

no air pressure is available, the contact bows can be temporarily actuated by means of a hand pump; as soon as contact with the line is established, the air compressors instantly commence to work. A small oil transformer of 7-kilowatt 3,000/110 volts carried on the locomotive platform and connected to earth serves the purpose of supplying the necessary power for driving the compressors, and also generates part of the current required for lighting.

The current is collected by the bow contacts, and connected through lightning arresters and a line switch to the emergency switch placed in the roof of the locomotive. From the emergency switch the circuits pass directly to two busbars, and then through fuses to the reversing switch, which controls the direction of working of the locomotive. Then they pass to the pole-changing device controlling the speed of travel, and lastly to the motors themselves. The third phase, entering from the rails as in the case of the other two overhead phases, first passes through the reversing switch and pole-changing device before reaching the motor.

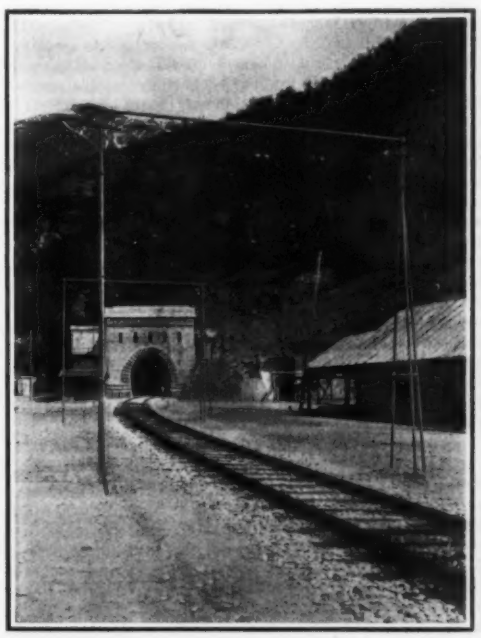
The controller is arranged to control all the apparatus requisite for the running of the train, comprising the reversing switch, pole-changing device, and starting resistances of the motor. It is of simple design, consisting of two handles, one of which governs the pneumatic operation of the reversing switch, and the other for pole changing, the resistances being regulated by a handwheel. The whole of the operations, except the regulation of the resistances, is accomplished by means of compressed-air relays, the general construction thereby being greatly simplified. The reversing switch comprises a wooden cylinder with copper blocks mounted thereon, and making the necessary connections with the fixed contacts. The same relays serve to operate the reversing switches for the two motors, and the locomotive can be reversed equally well with either of the two controllers. The pole-changing device is of exactly the same design as the reversing switch, there being only two positions corresponding to the two speeds of 21 and 42 miles respectively per hour.

The starting resistances are mechanically regulated as already mentioned by means of the handwheel placed on the controller. This wheel is geared to the contacts, which are mounted beside the resistances themselves, instead of being placed within the controller, as is the general practice. This departure from the orthodox gives a double advantage, inasmuch as it enables the controller itself to be of simple design, and secondly enables the contacts to be easily and quickly inspected and repaired whenever necessary. There is one set of resistances for each motor carried at each end of the locomotive beneath the engineer's cab. They are built of a network of rheostat wires having a high electrical resistance. To facilitate access to the resistances a number of inspection doors are provided on all sides, while to expedite removal when desired they are mounted on frames sliding in slots, and each can be removed independently. There are four ventilators placed in sets of two at each end for the purpose of artificially cooling the resistances. These are driven by small motors connected in the rotor circuits of the traction motors. When the main motor starts, the ventilator motors are immediately set in operation and are automatically cut out directly full speed is attained by the main motor, at which point the resistances are no longer in circuit, and there is consequently no need of ventilation. The valves controlling these various apparatus are not independent of one another, but are connected together pneumatically or mechanically, so that any mistake upon the engineer's part is adequately safeguarded against.

The emergency switch consists of a two-pole switch closed by the operation of a handle and capable of being opened in three different ways: (1) by hand, by the driver by means of a cord in a position close to the controller; (2) electrically, by the operation of an electro-magnet connected in series in the main circuit and coming into action when the current reaches a dangerous limit; and (3) by a compressed air relay which comes into use in the event of the pneumatic brake being applied too hard and rapidly, the object being to prevent any possibility of damage being inflicted upon the motors through the sudden stoppage of the train. Special attention has been devoted to the safeguarding of the engineers. It is impossible for them to handle the high-pressure apparatus, reversing switch, the pole changer, and current transformer while the collecting bow is in contact with the overhead conductors, as they are all inclosed in a sheet-metal partition which can only be opened when the collecting bow is withdrawn from the wires. The reversing switch and pole changer each operate under oil, and a special arrangement has been provided so that the contact cylinders can be easily and readily withdrawn for inspection.

Two Christensen piston type compressors driven by small electric motors serve for the supply of the compressed air, for the supply to the Westinghouse brake, syren, and sanding gear, in addition to the pneumatically-controlled apparatus. Each compressor has a supply capacity of 1,405 cubic feet of air per minute at a pressure of 110 pounds, to four cylindrical reservoirs which are mounted in pairs at each end of the locomotive. These compressors can be started either by hand, automatically, or by means of an electro-magnet regulator which disconnects the motors directly the pressure rises to 110 pounds, and which automatically switches them on again when the pressure falls below a certain minimum. All the compressed-air pipes may be operated from either end of the locomotive, they being fitted with return valves

THE INTERIOR OF THE TUNNEL, SHOWING THE MANNER OF SUSPENDING THE OVERHEAD CONDUCTOR.



THE BRIGUE ENTRANCE TO THE TUNNEL, SHOWING THE METHOD OF CARRYING THE OVERHEAD CONDUCTORS.

THE ELECTRIFICATION OF THE SIMPLON TUNNEL RAILWAY.

for this purpose, so that if either of these is not in order the engine can be driven from the other.

Two marble panel switchboards fixed to the side of the driver's cabin carry all the measuring instruments and low-pressure connections. The measuring instruments for the high-pressure circuit are supplied with current at low pressure from transformers, and are fixed to small marble panels mounted above each controller.

The engineer's cab is lighted by incandescent lamps so arranged as not to dazzle the operator's eyes. The switchboard panels are lighted by two incandescent lamps equipped with reflectors. In addition there are several plug contacts fitted for use with a portable lamp to assist in oiling and inspecting. The current for this supply is obtained either from the 7-kilowatt transformer used for driving the air compressors operating the collecting bows, or from the Aichele patent system, which is mounted on the locomotive.

Many objections are raised against the adoption of three-phase current for electric traction, but in this instance Messrs. Brown, Boveri & Co., to whose courtesy we are indebted for the information and photographs accompanying this article, are confident that they have overcome completely practically all the shortcomings, and that the system will prove more efficient in actual operation than any other system. The experience gained with the three-phase electric railroad at Valtellina has enabled the defects to be studied intimately, and also to devise the best methods of obviating them. For instance, excessive sparking, which characterized the Ganz locomotives, is avoided by the utilization of two bows for collecting the current, since it is very improbable that at any time the two collectors are simultaneously jerked off the overhead line. The objection, however, which is often levied against the three-phase system, owing to the fact that it involves a complicated system at crossovers and switches, is also denied; and in the accompanying illustration of a crossover at Brigue, the principle of arranging the overhead equipment is shown. It is of course obvious that at every point where a junction is effected the right-hand conductor for each track must be at the same phase, or else the motor would be reversed in passing. Therefore at each converging point the two inner wires of the four are of opposite phases, and it is quite apparent that a short circuit would be set up when the conductors came into contact with the collecting bow. To avoid this contingency the two inner conductors are made to terminate while still sufficiently apart to prevent their becoming connected by the bow, and are then continued by a completely insulated section for a certain distance. Insulation is assured by interposing strips of wood between this dummy line and the live conductors, and at the other end of the dummy section porcelain insulators are fitted. It will thus be seen that the dummy section in this case merely acts as a guide to the collecting bow. There being a collecting bow at either end of the locomotive, and placed some 27 feet apart, when the foremost collector comes into contact with the dummy section the current is being derived by the rear collector, while before the latter reaches the dummy section the forward bow is again in contact with the live conductors, so that the flow of current to the motors is in no way interrupted.

The railway department of the Swiss federal government, which is considering the project of electrifying the whole of the main railroads in the country, proposes to carry out a series of exacting tests upon this tunnel railroad, and will obtain comparative results concerning the operation of steam and electric haulage for railroads. Switzerland is peculiarly adapted geographically to the adoption of electric traction, owing to the abundance of water power which can be harnessed cheaply and economically. Moreover, the country is sadly deficient in native coal deposits, so that it is considered more economical and advantageous to the country itself to utilize the enormous water-power resources immediately available for this branch of commercial transportation. In the agreement made between the federal government and the engineers, the latter undertake to run the electric trains over the tunnel section at a fixed rate per train kilometer. The government, moreover, retain the right to abandon the system at the end of a year's working, and call upon the engineers to remove the whole equipment.

It has been frequently found to be penny wise and pound foolish to have been sparing in the depth of a reservoir puddle trench in order to lessen the quantities of excavation and puddle, and thereby save first cost. The result in such cases has invariably proved disastrous and costly by reason of resulting constant leakage of water and continual drain of expenditure in maintenance. There have also been similar unfortunate consequences by reason of the selection of the wrong materials for use in construction. One has frequently to investigate the impermeable and other qualities of brickwork, concrete, and puddle, and balance and consider their respective advantages from the points of view of efficiency, first cost, and ultimate outlay in upkeep. Then in kindred work, it is conceivable that in many circumstances economics may demand the use of rock asphalt for the waterproofing of surfaces rather than cement rendering, notwithstanding that the first cost of rock asphalt may at least be double the cost of cement rendering. Keeping in view the necessarily hard tear and wear, the coping of a dock-wall would be made of granite rather than of freestone, notwithstanding that a freestone cope would be about half the price of a granite cope; and the design of the dock generally would be considered from the point of view of avoiding continual dredging after completion, thereby saving cost in maintenance, even if to insure this the first cost in construction had to be considerably greater.

THE MANAGEMENT AND OPERATION OF SHIP AND SHORE WIRELESS TELEGRAPH STATIONS.—VI.*

By A. FREDERICK COLLINS.

IN transmitting and receiving wireless telegraph messages a dot and dash code is used just as it is in ordinary telegraphy. Since the one originally devised by Morse, numerous alphabetic codes have been brought out, but with one exception, namely, that of the Continental code, none have been employed to any considerable extent.

A ·—	B —···	C —·—·	D —··	E ·	F ··—·	G ——·
H ····	I ··	J ·———	K —·—	L ·—··	M ——	N —·
O ———	P ·——··	Q ——·—	R ·—·	S ···	T —	U ··—
V ···—	W ·——	X —··—	Y —·——	Z ——··	& ·—···	1 ·————
2 ··———	3 ···——	4 ····—	5 ·····	6 —····	7 ——···	8 ———··
9 ————·	0 —————	PERIOD ·—·—·—	QUESTION MARK ··——··	COMMA ——··——	COLON ———···	SEMI COLON —·—·—·

Table I.—American Morse Telegraph Alphabet

A ·—	B —···	C —·—·	D —··	E ·	F ··—·	G ——·
H ····	I ··	J ·———	K —·—	L ·—··	M ——	N —·
O ———	P ·——··	Q ——·—	R ·—·	S ···	T —	U ··—
V ···—	W ·——	X —··—	Y —·——	Z ——··	1 ·————	2 ··———
3 ···——	4 ····—	5 ·····	6 —····	7 ——···	8 ———··	9 ————·
0 —————	WAIT ·—···		UNDERSTAND —··—		DONT UNDERSTAND ···—···	

Table II.—Continental Telegraph Alphabet.

(*a*). The American Morse telegraphic code is in general use throughout the United States and Canada on overland lines, and nearly all wireless telegraph shore stations owned by private corporations, as well as coastwise vessels, likewise utilize the Morse alphabet. This code is formed of dots, dashes, and spaces, which in various combinations represent the letters of the alphabet and Arabic numerals, as shown in Table I. The length of time the circuit is closed determines whether the element is a dot or a dash, and similarly the length of time it is open determines whether it is a space between the elements of a letter or a space between a group of letters forming a word. A dash is made by holding the key down, i.e., closing the circuit, for a period three times as long as is required to indicate a dot. A space between the elements forming a word should be equal in length of time to a dot, while the space between the words in a sentence should be equivalent to that of a dash.

(*b*) Naval stations in the United States, on ship and shore, and transatlantic steamships, as well as land stations in Great Britain and on the Continent, employ a modified form of the Morse code and which is usually termed the Continental code. In this arrangement of dots and dashes there are no spaced letters, the alphabet being made up entirely of elements as shown in Table II.

The Continental code is somewhat easier to learn than the Morse, though either can be mastered with a little patience by memorizing those letters containing only dots, then those containing only dashes, and finally those containing both dots and dashes, and so on as shown in the classified Table III. The quickest way to learn to operate is to memorize the letters, the figures, and the punctuation marks before making any attempt to transmit them on a key. Since larger keys are employed in wireless telegraphy than in ordinary telegraphy, the speed of sending is necessarily slower, and should be if it is to be accurate, but the operator should be able to send at least twenty-five words per minute, although in actual practice even this number will probably be somewhat reduced. In sending messages the contacts of the key should be firmly brought together and enough time allowed for each dot to permit a sharp discharge to take place between the spark balls. As few punctuation marks as possible should be used, the period, semi-colon, and question mark sufficing for nearly all messages.

(*c*) In wireless telegraphy as in the ordinary wire system each station is called by a certain letter or letters. Where only two stations are in communication in the same effective area of action call letters are not so necessary, but where the stations are located in the vicinity of other stations—and it is difficult to find, especially on the Atlantic seaboard, a 250-mile radius where there is not a government or a private station or two—a call letter becomes absolutely essential, and it is also important that the letter chosen has not been adopted by some other station, as this would result in much confusion. To guard against such untoward circumstances, the call letters of the United States naval stations are given in Table IV.

Assume now that the newly equipped stations have had call letters assigned to them and that the operator at the first station, which we will designate A, is calling the operator of the second or complementary station B. He begins by transmitting the call letter, which for the purpose of illustration we will call A B, but he does not call continuously, as on an ordinary wire line, for operator B cannot break in; after calling two or three minutes, he stops sending and, throwing the aerial switch, listens in so that he may ascertain if B has heard his call and is answering. If he receives no affirmative signal in two or three minutes he repeats the call as before, and so on until an answer is forthcoming. In stations where there is a comparatively small number of messages to be sent each day a certain time is set when both operators are on duty, and a prearranged time and an understanding as to who shall call first greatly simplifies the procedure.

When the call is heard by operator B he replies by sending "I, I, I," and then his own call letter. The operator at the calling station should then state about the number of words he wishes to send; to this the operator at the second station signals "O. K.," when

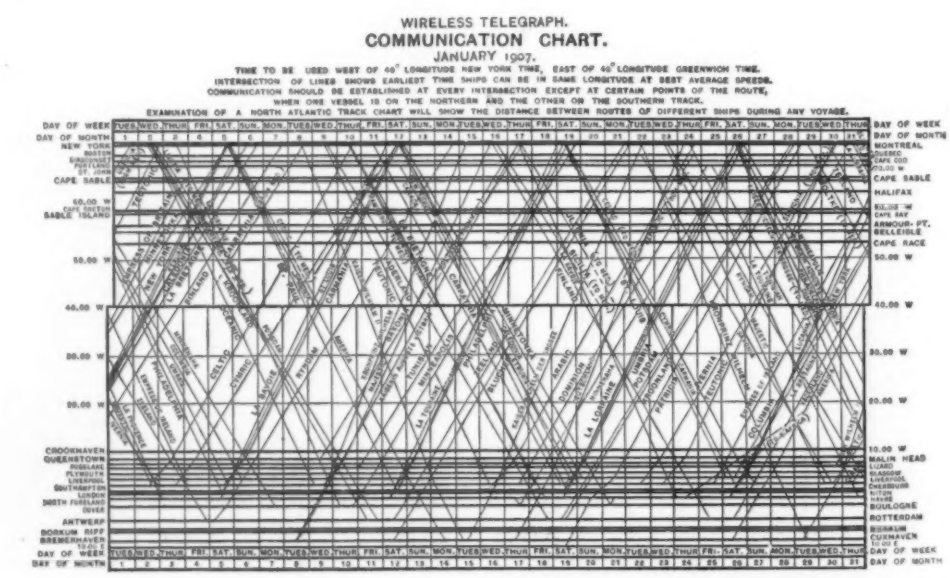


Fig. 8.—Communication Chart.

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT. This article should be read in connection with the following articles by the same author: "The Design and Construction of a 100-Mile Wireless Telegraph Set" (SUPPLEMENT 1605); "The Location and Erection of a 100-Mile Wireless Telegraph Station" (SUPPLEMENT 1623); "The Installation and Adjustment of a 100-Mile Wireless Telegraph Station" (SUPPLEMENT 1624); "The Adjustment and Tuning of a 100-Mile Wireless Telegraph Outfit" (SUPPLEMENT 1634); "The Theory and Action of a 100-Mile Wireless Telegraph Set" (SUPPLEMENT 1625).

operator A goes ahead. After each ten, twenty-five, or fifty words, as previously agreed upon, have been sent, operator A stops, giving operator B an opportunity to reply "O. K.," if he has heard, or "Don't understand" or "Repeat" if he has not gotten it all, as the case may be. When the message is all in, the fact is stated by the sending operator. If any portion of the message should be unreadable, the receiving operator should request the sender to repeat, and when the last of the misunderstood words are received he then signals "Go ahead."

Very often the call of some station may not be

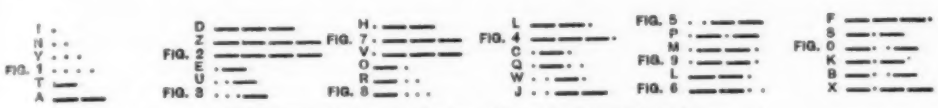


Table III.—Dots and Dashes of the Continental Code.

known to the operator receiving it, and especially is this apt to be the case if the station calling is aboard ship; under these conditions the operator receiving the call should send the letter "A" at intervals, as before mentioned, and then listen in for an answer. The abbreviations given in Table V. will facilitate the transmission of messages and increase the speed as well. A naval wireless telegraph station assumes the right to break in on any message being sent by a ship or a shore station if the business transacted is important; the right of way should be given at any time to a naval vessel or to any ship in distress.

(*d*) In "Regulations for the Government of Wireless Telegraph Stations," issued by the Navy Department, a rule is cited that all operators of stations of whatever character, public or private, should observe, to wit: "There shall be kept a log book in which shall be recorded the temperature, the direction and force of the wind, and the state of the weather by symbols. These records shall be made every four hours during the time the operators are on watch, and if there are not enough operators at the stations to permit of night watches being kept the maximum and minimum tem-

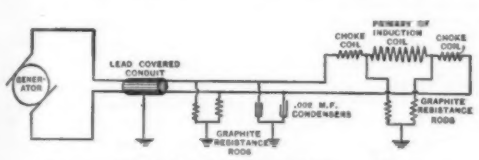


Fig. 9.—Protective Devices of Transmitters.

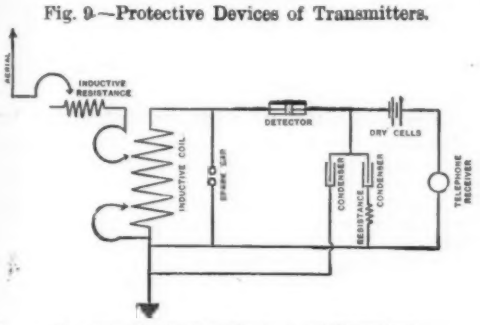


Fig. 10.—Protective Devices of Receptors.

perature during the night shall be recorded on the following morning.

"All meteorological phenomena, such as lightning, aurora borealis, fog, mist, snow, rain, etc., shall be remarked upon, together with a statement of the character of the transmission of signals, if any be made during the period. Whenever atmospheric signals interfere with the transmission all the circumstances of atmosphere and weather shall be carefully noted. The conditions of the weather which appear to be particularly advantageous, as well as those which appear to be particularly disadvantageous, shall be carefully observed and noted. Any regular recurrence of atmospheric signals shall be the subject of a special report.

TABLE IV.

Call Letters of United States Naval Stations.

Station.	Call Letters.	Station.	Call Letters.
Navy Yard, Portsmouth, N. H.	P C	Yerba Buena Island, Cal.	T I
Cape Ann (Thatchers Island).	P E	Navy Yard, Mare Island, Cal.	T G
Highland Light, Cape Cod, Mass.	P H	Cape Elizabeth, Maine.	P A
Nantucket Shoal Lightship	P I	Navy Yard, Boston, Mass.	P G
Torpedo Station, Newport, R. I.	P K	Naval Station, Key West, Fla.	R D
Montauk Point, L. I.	P R	Navy Yard, Pensacola, Fla.	R K
Navy Yard, New York.	P T	Naval Sta., Guantanamo, Cuba.	S I
Highlands of Navesink, N. J.	P Y	Panama Canal Zone,	S L
Cape Henry, Va.	Q N	Farallone Islands, Cal.	T H
Navy Yard, Norfolk, Va.	Q L	Naval Station, Cavite, P. I.	U T
Dry Tortugas, Fla.	R F	Naval Academy, Annapolis, Md.	Q G
San Juan, P. R.	S A	Navy Yard, Washington, D. C.	Q I
Culebra, West Indies.	S O		

The log book shall contain a list of the stores expended, a record of the number of hours the engine or other source of power supply is in use, of all accidents and repairs to any part of the apparatus, and all other matters of interest. The log book shall contain a list of messages sent and received, the number of words and time of transmitting and receiving each message, the distance and wave length, and for sending, the spark-gap and power used for each message." In Table VI. the wind symbols are given, while Table VII. indicates the weather symbols.

(*e*) Ships are located in the Atlantic Ocean by means of a communication chart shown in Diagram 8. There are over eighty passenger steamships plying between the different transatlantic ports that are equipped with wireless telegraph apparatus. As these ships have predetermined dates for sailing and sail on successive days the ships are separated at all times by a practically uniform distance. This arrangement is not only a convenience to passengers, but acts as a safeguard against collision between steamers at sea, and serves a third useful purpose in forming a complete chain of wireless telegraph stations across the ocean at all times; indeed, it is seldom that an area of more than 100 miles is without two communicating vessels.

To facilitate the transmission of messages between any two ships or any ship and any shore station the Marconi company issue a communication chart at the beginning of every month. It will be observed that New York time is to be used west of 40 degrees longitude and Greenwich time east of 40 degrees longitude. The intersection of the lines on the chart shows the earliest time that given ships can be in the same longitude when making the best average speeds.

Communication should be established at every intersection, except at certain points of the route when one vessel is on the northern and the other is on the southern track. An examination of the North Atlantic track chart will show the distance between routes of different ships during any voyage. At the end of the month for which the chart was plotted the ships may drop a trifle behind their schedule time, but the chart may be kept accurate enough for telegraphic purposes by checking off the delays with a pencil as they occur.

TABLE V.

Telegraphic Abbreviations in Common Use.

About	Abt	Mail	Ml
Again	Af	Money	Mon
All right	O K	Message	Mag
American	Amn	Mistake	Mak
Amount	Amt	Million	Myn
Answer	Ar	Necessary	Nec
Arrive	Arv	No more	N M
Atlantic	Atl	Office	Ofs
Ask	Ax	Operator	Opr
Balance	Bal	Per cent.	Pc
Before	Bf	Paid	Pd
Back	Bk	Post-office	Po
Between	Btn	President of the	Pot
Business	Bz	Quick	Qk
Battery	Bat	Receive	Rc
Charge	Chg	Receipt	Rct
Connect	Cx	Report	Rp
Capital letter	Cx	Seen	Sen
Collect	Col	Signature	Sig
Check	Ck	Sailor	Slr
Delivered	Dld	Steamship	Ss
Dollar mark	Sx	Street	St
Deadhead	D H	Station	Stn
Engine	Eng	Service	Sve
Et cetera	Etc	See	C
Extra	Exa	Seeing	Cg
Field	Fld	See your service	S Y S
Freight	Frt	Telegraph	Tgh
Give better address	G B A	Telegram	Tgm
Go ahead	G A	Thanks	Thk
Give some address	G S A	Time	Tl
Good morning	G M	Ticket	Tkt
Good evening	G E	Thousand	Tnd
Good night	G N	Water	Wat
German	Ger	Weather	Wea
Going	Gg	Western Union	W U
Has been	Hb	Yesterday	Ya
Hundred	Hnd	You see	Uc
It is	Ix	Please start me	4
It is understood	I x U	Have you anything for me	5
Know	Kw	Important official message	9
Latitude	Lat	Understand	13
Leaving	Lvg	I am busy now	25
Material	Mat	No more	30
Maximum	Max	Accept best regards	73
Minimum	Min	Message for you	77
Machine	Mch	Deliver	92
Manager	Mgr	Give instant possession of line for test	"Wire"
Minute	Min		
Market	Mkt		

By means of the chart an operator at any ship or shore station is enabled to reach any other ship, all the way across the Atlantic if need be, by using intermediate ships as relay stations.

(*f*) To get the best results a station is capable of giving, the oscillation circuit must be protected from leakage. Where the stays of the mast are of wire cable there is always a loss of energy, for the electric waves emitted by the aerial will set up oscillations in all conductors that parallel it, especially if these anywhere nearly approximate its length. For this reason the wire cable stays, if these are used, should be insulated from the earth in shore stations and from the hulls of ships by hemp lanyards, and to further circumvent the dissipation of energy the wire cables should have wound around them a large number of turns of very fine soft iron wire, say No. 25 or 30 American wire gage; these serve as choke coils and throttle the energy which would otherwise oscillate through them. The better way, where possible, is to use hemp rigging throughout.

(*g*) The low-tension circuits should also be protected against lightning and other high-potential discharges. Care should be exercised to prevent the conductors of which the low-voltage circuits are composed from being placed in a position where they will parallel the lines of the high-potential circuits, not only of the instruments forming such circuits, but from light and power circuits, especially those carrying alternating currents, for under such conditions high potentials may be induced that will burn out some portion of the apparatus or cause fires.

Where dynamos are used for generating the current instead of batteries specified in my first paper, there is danger at all times of the high potentials developed in the oscillation circuits inducing similar high potentials in the low-voltage circuits, which include the armature of the dynamo and the primary of the induction coil, in which case the insulation of either may be punctured. These dangers may be minimized by resorting to various protective devices such as choke coils, condensers, spark-gaps, grounds, etc.

Beginning at the terminals of the dynamo or other source of electromotive force, it is considered good practice to use lead-covered wires and ground the covering as shown in Diagram 9. Shunted across the

TABLE VI.

Wind Symbols.

		Statute Miles per Hour.			Statute Miles per Hour.
0	Calm	3	7	Strong breeze	40
1	Light wind	8	8	Moderate gale	48
2	Light breeze	13	9	Strong gale	56
3	Gentle	18	10	Gale	65
4	Moderate	23	11	Heavy gale	75
5	Stiff breeze	28	12	Hurricane	90 and over
6	Fresh breeze	34			

NOTE.—A statute mile is the legal mile of the United States and measures 5,280 feet. A nautical mile is one-sixtieth of a degree of the earth's equator.

circuit, condensers and carbon resistance rods can also be used to advantage, and finally the primary leads of the induction coil should be provided with choke coils formed by ten or twelve turns of copper wire.

(*h*) While it is impossible to prevent interference between various stations, it is well to choose a wave length different from that used by the United States navy or the commercial companies. The length of wave used by the navy is at present 425 meters, having been increased from 320 meters, which was formerly employed, but the longer the wave length the more effective will be the radiation where land intervenes between the stations.

The formation of electric waves by lightning discharges, or static, as the operators call it, is another source of interference that in the warm climates of the South and the protracted dry weather in the North gives a great deal of trouble. The difference of potential between the strata of the air at the upper end of the aerial and the earth is constantly being equalized through the aerial wire circuit, though certain periods of the day, seasons of the year, and conditions of the weather also affect the transmission of messages.

It seems paradoxical, but when the air is full of humidity the propagation of the electric waves takes place to the greatest distances. This is accounted for on the theory that when the atmosphere is perfectly dry it becomes ionized and when damp its ionization is eliminated. Hence, a very efficient station should be designed to transmit three times the effective energy really required under favorable conditions. Condensers in the earthed terminal and micrometric spark-gaps shunted around the detector, as shown in Diagram 10, aid somewhat in eliminating the disturbances that statics or strays set up in the detector.

A high frequency of interruption in the low-voltage sending circuit renders the reading of the signals in the telephone receiver much clearer than when a low-frequency make-and-break is used, especially when the atmospheric disturbances are continuous, as the note produced by the diaphragm of the receiver is higher and more penetrating. If the static discharges are continuous and the signals otherwise are coming in clear, the operator may disconnect the ground terminal to his receptor, and while the signals will be weakened the static effects will usually be cut out, or at least very greatly diminished.

(*i*) The Bureau of Equipment of the United States navy has recently issued the following statement to naval operators concerning telephone receivers to be used in connection with wireless telegraph receptors:

1. The headgear will consist of two watchcase telephone receivers, mounted by universal joints on an adjustable covered strap, and arranged so as to be conveniently held on the head of the operator.

2. The receivers are to have a powerful permanent magnet and to be wound with silk or enamel-covered copper wire having a diameter over the copper of not less than 0.0015 inch; the diaphragm to measure 1¾ inches in diameter and have a thickness of 0.004 inch. The last few turns on the coils will be of heavier silk-covered copper wire; all the joints are to be rosin-soldered. The resistance of each receiver will be between 1,000 and 1,100 ohms.

TABLE VII.

Weather Symbols.

Clear blue sky	(b)	Passing showers or rain	(p)
Cloudy weather	(c)	Squally weather	(q)
Drizzling or light rain	(d)	Rainy weather	(r)
Fog or foggy weather	(f)	Snow, snowy weather	(s)
Gloomy or stormy looking weather	(g)	Thunder	(t)
Hail	(h)	Ugly or threatening weather	(u)
Lightning	(i)	Variable weather	(v)
Misty weather	(m)	Wet or heavy dew	(w)
Overcast or dark weather	(o)	Hazy weather	(z)

3. The two receivers will be connected in series with a flexible cord, giving a free length of at least four feet. The cord will consist of two rubber insulated conductors with pin terminals at both ends. The conductors will have seven strands of No. 32 Brown & Sharpe gage copper wire or the equivalent. The cord from each telephone will be joined 15 inches from the receivers and continued for 4 feet and 6 inches; joints to be neatly made. No part of the cord to have more than two conductors; the conductors will

be covered and held together with a green silk braid.

4. The strap will be of nickel-plated steel, covered with a thin coating of black hard rubber.

5. Each receiver will be fitted with pneumatic ear cushions of approved type.

6. Weight of set not to exceed 15 ounces.

7. Each set will be supplied with one extra cord complete.

8. Each telephone will be tested for receiving qualities and must give results equal to standard sample.

ELEVEN YEARS OF AUTOMOBILE DEVELOPMENT.

Baron de Zuylan de Nyevelt, having been requested by the Echo of Paris to summarize the progress that has been made by the automobile since he has presided over the destinies of the Automobile Club of France, has sent to that journal the following very interesting article:

"I had scarcely left the university in 1879 when my first business was to visit the establishments of mechanical construction where I made known my plans of driving carriages mechanically to the engineers commissioned to receive me. It is useless to add that these scientists looked upon me askance and answered that my idea was ridiculous and impracticable.

"Despite these disinterested opinions I employed the greatest part of my time and income in having different types of carriages constructed, some of which, I must confess, ran worse than the others. The last in date was constructed in 1893. It was provided with a gasoline motor, but could never make more than five kilometers (3.1 miles) an hour.

"I had reached this point in my experiments, when, in July, 1894, being in London, I read in the Petit Journal that at the initiative of MM. Marinoni and Pierre Giffard, a great competition of mechanical carriages was to take place between Paris and Rouen.

"I took the first train and reached Paris just in time to see the automobiles get under way.

"I organized four relays of carriages drawn by trotters so that I reached Nantes long before the first automobile. I afterward took the train and reached Rouen to witness the entrance at full speed of the steam brake driven by M. Bouton, and carrying, if I remember rightly, M. de Dion and Capt. de Place. I then proceeded to the Hotel d'Angleterre, where the rendezvous took place, and, approaching Count de Dion, I congratulated him upon his success and said to him: 'My dear friend, we must really organize a great automobile race and offer some very important prizes in connection therewith. If you are willing to open a subscription list you can write my name at the head of it for any amount you desire.' 'Very good,' said the count, 'but I had conceived the same idea as you, and this very morning Mr. James Gordon Bennett desired me to write his name under the same conditions.'

"We afterward exchanged ideas as to what such a race should be (the most arduous one that had ever been organized, 744 miles without stop either day or night). A committee was formed, at the head of which were placed Mr. Bennett, Count de Dion, Marquis and Count Chasseloup-Laubat, Georges Berger, and MM. Depres, Menier, Marinoni, Empair, Giffard, Meyan, Recope, de la Valette, Varennes, Vanderbilt, etc., and the manufacturers Levassor, Peugeot, Jeantaud, Bollée, etc. The Paris-Bordeaux race took place June 11, 1895, and was won by Levassor, who never left his carriage for forty-eight hours. The enthusiasm was indescribable; Levassor was carried in triumph. We had succeeded in rousing the public from the lethargy in which it had been slumbering for ages, and a bond had just been established between manufacturers and their future customers—the adepts of the new locomotion. The automobile industry was born.

"The fellow-feeling that had been engendered between the members of the Paris-Bordeaux committee was so warm that Count de Dion declared that to allow such forces to become scattered would be a capital crime.

"The first meeting took place at Quai d'Orsay between MM. de Dion, Paul Meyan (then editor of Figaro) and myself, in order to lay the base for the foundation of a club. A second meeting, at which MM. de Dion, Meyan, Recopé and I were present, was held at Avenue Jena for the elaboration of the by-laws. A third meeting took place in one of the rooms of the Café de Paris; and, finally, on the 12th of November, 1895, the entire Paris-Bordeaux committee was called together by Count de Dion at his Quai d'Orsay house in order to proceed to the definitive foundation of the Automobile Club of France.

"The gathering did me the honor to select me as its president. I observed to my friends that while this mark of esteem touched me deeply, it created in me a delicate feeling, for I was of Belgian nationality. Notwithstanding this, however, I was elected by acclamation. It was the wish of M. de Dion, whom I had proposed for the presidency, to accept the office of vice-president merely. I have been particular to recall these remote reminiscences because I attribute to the accident of my meeting Count de Dion at Rouen on the 22d of July, 1894, a preponderant influence on the future of the new locomotion. It was, in fact, dating from this moment that the automobile industry finally made its exit from the exclusive domain of inventors in order to enter the triumphal path on which our successive manifestations have placed it.

"I may remark, moreover, that it was the programme elaborated in July, 1894, that has been followed step by step during the past eleven years. I cannot finish this article without offering an homage of gratitude and admiration to the early laborers who so greatly contributed to the triumph of our ideas. I cannot name them all here, for want of space, but I must at least mention those of Count Gaston Chasseloup-Laubat, Levassor and Forestier, whose memory will ever remain green in our hearts.

"Constant mention is made of the 500,000 persons in France living directly or indirectly on the automobile industry, and of our exports to the amount of a hundred million francs; but I am persuaded that such prosperity is nothing as compared with what the future has in store for us.

"It is merely necessary to glance at our streets, highways, and boulevards and to contemplate the thousands of horses still traversing them to see that if all do not disappear in one day, the most unfortunate at least will soon cease to sadden us by the sorry spectacle of their slow agony. The automobile industry is to-day a classified one, more prosperous than many others because it responds to more pressing needs. It is therefore the moment for the founders of the Automobile Club to contrive to advance to the front and to persevere in the contest that they have undertaken against prejudices and routine.

"What a fine programme still remains for them to carry out! How much progress has not been obtained, solely because the indifference of men has not constrained the genius of inventors to occupy itself therewith!

"By the same processes that we have employed for the last ten years I should like to see a development of the following ideas, which are to the highest degree worthy of attracting the attention of men who are young enough, rich enough, and intelligent enough to hasten the realization thereof.

"(1) Aerial navigation by flying machines.

"(2) Very rapid maritime navigation by means of turbine, electric, and gasoline motors.

"(3) The carriage of travelers at great speed by subterranean tubes and by aerial electric tracks (say a minimum speed of 125 miles an hour).

"(4) The creation, by automobile societies and syndicates, of special roads permitting of the use of very swift carriages. A like demand has been submitted to the House of Commons for the creation of a road between London and Brighton. A project is also on foot for a road between Biarritz and Arcachon."

OUR COAL.*

By F. Z. Schellenberg.

The United States has produced 6,000 million tons of coal, and the annual rate now is 400 millions, against 200 millions in 1897 and 100 millions in 1882.

Besides our annual production of 80 million tons of Pennsylvania anthracite, we get 200 million tons of bituminous coal from Pennsylvania and the adjoining States of Ohio, West Virginia, and Maryland; the sixth part of which 200 millions is made—in Pennsylvania and West Virginia—into coke, being fully 25 per cent of the country's production of coke. Alabama, Virginia, and Colorado make another 15 per cent.

The annual production of coke has quadrupled in the last twenty-five years and is now about 33 million tons. Nine-tenths of all is yet made in bee-hive ovens. Coke is mainly used for smelting iron ore, in a total production for the United States of 23 million tons of pig iron last year.

Around the heads of the Ohio River cluster the grosser manufactures dependent primarily on cheap fuel. Of the 35 million tons of coal mined in the Pittsburg district the one-half is consumed there, a combination of freight tonnage and surplusage unequaled in all the world.

The coal from the mines of Western Pennsylvania and adjacent is all of the flaming soft coal or bituminous varieties of the market; whether it has come from the Pittsburg seam, or from the Freeport seam which lies nearly 600 feet lower in the series of rock measures, or from the Kittanning seam 175 still lower, or from the less broadly prevalent prolific seams occurring between or above and below the three named.

The newer of these seams give a decidedly reddish brown streak in rubbing lumps together, while anthracite is really black. We are reminded that full burned charcoal is really black and burns without smoke or flame, but that for some gunpowder-making there has been used a less charred wood coal, the more inflammable *charbon rouge*.

Unlike the anthracite beds with their hardest conchoidal fracturing stone coal in those most uptilted, we have the softer coal of the seams at the east, in the more inclined positions; but like the anthracite the percentage of fixed carbon reduces—from 75 to 50—with flatter lay as we come northwest from the mountains across our carboniferous table land. As was the composition affected to lessen the fixed carbon and have increased proportion in volatile matter, so was the texture, by the crowding movement from the southeast that had been mountain-making farther back east and gradually weakened northwestward.

At the west we have the lumps breaking from the coal vein rather according to the bedding joints, in long flat pieces.

But about Pittsburg we have a preferred raw fuel, the gas coal, in large firm sharp-edged cuboids, as selected lumps after careful mining separating out the well-defined slate bands of the vein.

Then, at the east in the coke region proper, we find the same vein, thicker and softer or more tender, easily dug promiscuously to slack or frail lumps of crumbly small cubes, and thus hardly separable as pure coal from the intermingled earthy matter which is scarcely segregated there into plate slates—the coal seam there being vertically fissured through closely and made columnar in grain.

All the differences noted as in geographical sequence agree as consequences of the later side pressure change westward over the whole body of rock strata, originally deposited flat, warping it into basins, etc., with decreasing rate of the dips and the cleavages less near together.

We have here the cleavage direction in parallels ranging 65 deg. to left of the meridian (as the line of smooth faces or "bord" in the coal veins) across the basins; and the normal, 25 deg. to right of meridian, is the easiest for quarrying or mining out product (called in the mine "on the face of the coal") which direction, with the other along the cleavage "on the butt" of the coal, makes a rectangular system of development by entries in the coal seam.

But the gradients in such straight mine drifts cannot be regular, for "the strike" or level line in the stratum is affected by the pitch of the basin on the trend of its trough axis (the synclinal), extendedly showing more at the surface by the anticlinal crests between basins being on broken lines and undulating in elevation with a general rise northeastward of 20 feet to the mile; in less complication, but adding to the variations in position, the stratagraphic cross-section northwestward shows a profile of reduced waves and declining as to its surface line from the erosions, until the covering glacial drift is met.

In a flat coal mine, besides such rectangular system of face entries (on the face) and butt or cross entries there are apt to be other diagonal drifts, perhaps nearer the conforming contours, for drainage or transport favored by gravity, or as long straight avenues graded in refinement from the natural drift elevations.

The charting of the mine workings required every six months to show, on scale not smaller than 200 feet to the inch, the open and closed spaces mined out, needs only to be on the horizontal plan. On these maps the entries are seen to be in pairs, so driven particularly to have the air current making the round by short cut-through every 40 yards. The air's turn may be extended to the face in its progress by carrying forward from the last cut-through a temporary partition, in the entry along the "rib" (pillar) of canvas or boards and called a "brattice"; the cut-throughs being closed successively by "stoppings" to have only the last one open for the air current thus directed.

The coal seams are found to be thicker in the trough or depressions, and thinner over the next connected hills, than the extensive normal thickness, and the contrast appears within short distances in the "swamps," the small sub-basins only likely found in the practical progress of a mining venture.

Away from here much more frequently than in our Pittsburg field do we find "pinching out" of the vein's top measures uncertainly alternating with upper extra thickening; but we have "clay veins" as dislocations from bottom to top with twisting of the measures centering about the joint filled in with indurated clay, etc.

These are not dignified as "faults" because not markedly affecting the general uniformity of size and position.

The most important, the Pittsburg coal seam, is wonderful in its persistence and the resemblance of its cross-section of measures throughout its great width, although gradually changing dimensions. It has the bands as two thin slates with a few inches of coal between, about the middle of the height of the section, under the bands it has the double bottoms, partially or wholly contributing to product; underneath is fire clay which, as often very hard from contained iron nodules, is erroneously called the bottom limestone; above the bands is the good coal; the breast and atop is a fire clay about a foot thick about here where it has to be regularly taken down in mining, is called the draw slate, and is in some localities all saved for the manufacture of refractories. Above this part of the section that makes the regular open work in the mine, is the roof coal, rarely mined for product.

The proper mining out of a seam is a kerfing or undermining along the bottom of the face or above in a softer measure of the section, or below in underclay; secondly is the shearing, a vertical kerfing at the side, or middle it may be in wide face; both preparatory to blasting with light shots, instead as formerly the taking down by wedge and light pick and as might be the taking up of bottom with heavy hand pick; all with the purpose of securing lump coal as a specialty.

Blasting from the solid face is reprehensible. Especially so where the heavy shots flaming and in volleys are directly dangerous, and where in hard coal with narrow room pillars these are shattered perforce. The difference in the manner, in the extra labor and less powder of real preparatory mining, is to have a "loose end" or loose bottom, or both, made by the kerfs extending back 4 to 6 feet, with the care to have the two or three shot holes across the face not deeper.

Power machines have largely superseded the hand pick for making the under cutting, and with them is the tendency to rob the pillars (even to thinness, allowing them to go to waste) in widening the advancing room face instead of leaving the pillars full width intact for complete withdrawal (by some hand work) in the retreat which should be a recovery of all the coal left as support along the advance, but should also in systematic detail of procedure be for a controlled settlement of the roof strata. And further, as entry driving is work paid for on the tonnage basis wholly, or partly only on lineal yardage, the entries are made too wide—more than the 8½ feet width ample for

* Engineers' Society of Western Pennsylvania.

track etc., and the roof is made unstable, hardly to be corrected by a row of posts objectionable anyhow, and giving space presently to be occupied by dirt under its general definition of matter in the wrong place. Trouble is entailed to add to the coming "squeeze" when in automatic settlement of the overburden in wide room areas left half open, the stresses are shared around to be magnified, and involve even some near solid coal areas in strain prohibiting future mining there; the integrity of the whole upper stratification being widely impaired.

In the interior of our mines, as not very deep, the temperature is constant at about the average of the year at the surface, here 57 deg. F. Small outcrop mines have natural ventilation as upcast at higher openings in the winter and downcast there in the summer, or baffling between day and night, at the two seasons of the year when the outside temperature is the same about as the inside.

Artificial ventilation, generally now compulsory, has become scientific. It is by furnace, giving a heated motive air column, or exhaust power fan, to draw out the laden vapors or by blowing power fan to force in air, at one or two inches water-gage pressure difference, and thus having circulating air currents, directed and so "split" inside, between cared-for openings outside opposite, as intake (downcast) and return (upcast).

Coal mines where explosive gas has been detected are classed as gaseous mines, and a reading of the Bituminous Mining Laws of Pennsylvania, providing for the lives, health, safety, and welfare of persons employed therein, is interesting as to this class of mines distinctively.

Natural gas found in the coal seam itself has come from the part extending below water level to exude in the mines palpably at the advance faces on the solid ahead of ventilating excessive air current, or it may come in from higher carbonaceous strata broken into by fall of roof, or be tapped in abandoned gas and oil borings which reach deep, here 2,000 feet below the Pittsburg coal seam, to coarse—but tightly covered—strata, holding as reservoirs those fluid hydrocarbons.

In the mines the gas from fresh broken coal face diffusing into the atmosphere can generally be lighted at its source quietly in the presence of excess of air; and as firedamp, the admixture of the gas with air, is as low as 2 per cent, detectable by its elongation of the flame in safety lamp held up, in test of the accumulation at the roof. In imperfect ventilation with gas exceeding 20 per cent the lamp goes out. The explosive range is in mixtures of one gas to five air and one gas to fifteen air; the mean of 1 volume of pure gas to 9.6 volumes of pure air is the most explosive.

We have this gas heating our houses, and seek to have that mean of dilution giving a blue flame, from perforations in burner box supplied by gas jet surrounded by air mixer; the distribution in street pipe system being finally at ¼ to ½ pound pressure per square inch, as reduced from high pressure—even of hundreds of pounds—in the main conveying pipe lines.

Natural gas as nearly light carbureted hydrogen (CH_4, specific gravity 0.56) has half the gravity of air.

Black damp of the mines is carbonic acid gas, nearly carbon dioxide (CO_2), and has one and one-half times the gravity of air. It is in all the atmosphere of the earth at 3 parts to the 10,000 of air, equal to 0.03 per cent.

Alex. Silverman ("Proceedings of the Engineers' Society of Western Pennsylvania," December, 1903) found the air in Allegheny schools about May 1, 1902, to contain 0.04 to 0.20 per cent carbon dioxide. And it is declared ("Treatise on Ventilation and Heating," B. F. Sturtevant Company, Boston, Mass.) that assuming the external air to contain 0.04 per cent dioxide, the dilution by the supply of 100 cubic feet of fresh air per minute to each person in inclosed space will keep the vitiation to the tolerable content of 0.05 per cent of dioxide; there being an accepted production of 0.6 cubic foot of dioxide per hour by an adult at rest, the calculation for the increment of 1 part in 10,000 is 0.6 divided by 0.0001 equal 6,000 cubic feet per hour. It is stated that only 4½ cubic feet of fresh air per minute are required if the 400 parts dioxide in 10,000 parts in spent air of the lungs be immediately removed without contaminating the atmosphere.

Having in mind that the diffusion of gases is inversely rapid as their specific gravities, we see that black damp is less easily removed than firedamp; it lies in low areas of half-open abandoned places (where, too, firedamp may lurk) it is a product of all slow but complete combustion of organic or mineral carbon decay, and animal respiration; and rapid, of fire.

As regards humidity, the healthful limit in air of the mines would be 1½ per cent; for a pound of saturated air at 32 deg. F. contains 25 grains of water vapor and at 60 deg. F. 100 grains.

White damp is the name given to carbonic oxide (CO) and as monoxide from the addition of one atom of carbon to the dioxide, its presence signifies imperfect combustion. We get it cold from fresh coal on a grate or hot from a blown-out shot in the coal vein. It is, of course, inflammable, as being ready in its affinity for an increment of oxygen; it reaches for this with energy when heated. It is the most noxious to the animal economy, not merely suffocating like the rest but a deadly poison on inhalation.

About dust alone being explosive, there is difference of opinion; but doubtless it will, as it is heated, propagate explosion.

On explosion of gas there results nitrogen, steam, and carbonic acid as the suffocating afterdamp mixture, and there is deposit of soot on the cooling with that quick expansion showing for only limited dusty spaces being involved.

The suffix "damp" in firedamp, black damp or choke damp, white damp, and afterdamp is in origin the same as *dampf*, the German word for steam or vapor.

A gas explosion in the mine from accumulation meeting the air and fire, or in the street from a leaking pipe, is a double one; the vacuum created behind induces a quick flow from the source and indraft from the atmosphere for a second weaker detonation than was the prime one which had come after filling a space and pushing to air current.

The mining law requires the circulation of 150 cubic feet of air per man per minute and as much more as will dilute, render harmless, and carry off the noxious gases generated in the mine.

Variations of the barometer indicate changes of the atmosphere's weight constantly; the extremes of pressure differ here during every year by 100 pounds per square foot on all open surfaces. High barometer may mean a penning in of the gases in the strata, and then lowering barometer their quick release at open faces.

Locked safety lamps only are used for mining in the presence of gas, as for making the initial air-ways through the solid to conduct the ventilation in circulation from intake to return air-ways. And these lamps are necessary when the roof is to be broken; as it should be under control for proper settlement in retreat work at the beginning of drawing room pillars, because the subsidence of the roof strata may bring down some gas; and the lamps are necessary, precautionary, where gobbed old places are to be broken into.

There are mines in which locked safety lamps are exclusively used, by order of the remoter management of the business or periodic inspector, in warding off responsibility, rather than by the competent officer in charge of the work. The Wolf safety lamp, made in Germany, burning naphtha with somekeless light, and openable only in presence of a large magnet, is preferred for such general use.

But the common worker in the coal mines ought not to find gas to hurt him if his place and the whole panel of workings is properly inspected daily and ventilated, and he ought to carry the center of his sphere of illumination on his cap to guard him up, down, and around, in greater scope of open quantity of light than does the safety lamp lantern. (Fatal accidents inside are now from falls of roof and sides 67 per cent, from gas 9 per cent, and from explosives 4 per cent.)

The changes for greater tonnage are with more machinery in every place inside and outside, with men of the Slavonic races, and blasting powder in quantity experimentally flameless, and not yet everywhere resulting in safe economic extraction of the coal seams, but with continued waste of the store in the ground.

Socialism, management by the State of coal mining and transportation is being continually called for, unfortunately; but some of us think that fundamental justice simply applied in taxation of land values, *only*, for the public's benefit that collectively makes these values, should lead off and would in equity do away with the need for invoking the governmental interference between capital and labor. The very existence of a community of men (society), with individual liberty in right relation to it and each other is at stake, some say. Politically, we should be wise and happy to see carried out the democratic doctrine of "equal rights to all, special privileges to none," and maintain free discussion with social order.

The fatalities in the bituminous mines of Pennsylvania were last year 444 killed inside and 35 outside; that is, one life was lost out of every 345 employed, or as the comparative statistics for the years have it, 2.90 lives per 1,000 employed, or one life for every 249,000 tons of coal produced. The total for the year was 119,361,514 tons of bituminous coal. This country throughout has had an increasingly bad record as compared with others in accidents in mines, etc. But Pennsylvania last year showed some improvement.

For the year 1905 the list is:

Killed from falls of coal	52
Slate and roof	246
Mine cars	57
Machinery	9
Explosion of gas	29
Explosion of dynamite and powder	7
Explosion of blasts	9
Suffocation by gas	10
Falling into shafts	5
Miscellaneous	20
	444
Outside	35
Total killed	479

Of all, gas accidents are 8 per cent; from falls, percentage has increased in thirty years, 40 to 62. Last year's electricity column is vacant.

The marketing of our bituminous coal is generally in the four grades straight or variously mixed together: The *lump*, run over screen of 1¼-inch spaces between parallel bars; the *nut*, through, then run over ¾-inch straight spaces, or bumped over such less inclined shaking screen, or through holes in revolving screen; the *slack*, that falls through both; and the *run of mine* of the three unseparated, but mostly misnamed so hereabout as the first screening is required with stop to weigh the lump for the miner's pay and then one or both the screenings, on their way in the chutes, may be brought in and the grades together loaded into the railroad cars under the tipple; or the grades can be directly separately loaded according to the demand of the market. Here, screened coal apportions about 66 per cent lump, 14 nut, and 20 slack. The solid coal weighs about 80 pounds per cubic foot.

The comparison of freedom from large and small size impurities of the coal vein, as differences in the grades depends upon the manner and means of mining. Heavy blasting from the solid face in the mine, that is, without preparatory mining, among other results bad, generally prevents the selection which is feasible inside (owing to the great regularity of the measures of a vein) with discriminative pick mining or partly machine undermining (all that the power machine can do) and partly hand pick work, as preparatory to lighter blasting and selective loading of the product into the mine cars—unlike this the anthracite is cleaned of slate outside the mine, after the breaking between power rolls; the slate being picked out before and after the various screenings over spaced bars and through square-meshed revolving cylinders, to have a numerous series of clean uniform sizes kept separate.

Among the impurities the sulphur seen everywhere, as brassy iron pyrites ($Fe S_2$) incrusting the "clean coal" is of less import there than it is generally in the "binder" slates it makes heavy. There occur sulphates of lime and of alumina as curiosities. Organic sulphur, as compounded with carbon and hydrogen, is not in evidence except by analysis, adding to the percentage of sulphur, nor does it clinker the ashes separating as the waste in fires. Sulphur as a fuel has about one-fourth the value of carbon.

In the present coke regions separation of the earthy matter, the slates, is scarcely required, and what is wanted in the ovens is the smallest lumps to favor the charring to homogeneous coke; the vein readily yields a friable product to pick or powder.

In the coke region in contradistinction to the gas coal region, the working of mine rooms is narrow (of 4 yards width, with one row of props, against the 7 to 10 yards in the hard coal) and the retreat is of wide room pillars (even exceeding 20 yards) taken, drawn out, totally obtained as product—together with the "heading" (entry) pillars from the inner end of a section of the mine in diagonal line running between face and butt in range of the faces working, for systematic exhaustion and closing in, with purposed subsidence of the roof and relief therefore from "squeeze" as extended pressure hanging over, or "creep" as raising of the entry footing and tracks from displaced soft clay forced into the open from under the weighted pillars alongside, by live roof.

The burning of bituminous coal we all understand is not necessarily a smoke nuisance. At replenishing of the fire the heavy hydrocarbons dislodged at the start give out brown tarry vapors and then as they split up, water vapor and burned gas; but with the great absorption of the heat this vapor is in the vesicular form of steam and blackened by particles of condensed carbon; and the cloud of smoke coming only for a minute, and it may be only once in fifteen, unfurls to stain the environs. After our Prof. Trinks the case may be stated thus: Ample supply of preheated air above the fire of the boiler furnace to burn the carbon as well as the hydrogen at the time of stoking, is the preventive. That supply automatically issuing from pipes placed for the purpose, at the proper time, prevents also the non-conducting soot deposit on the shell, and there is a raising of heat effect from 72 per cent to 82 as the fuel's total yield to the boiler. The theoretically perfect, even dosing of sized coal upon the shaking grate of the mechanical stoker may, at a vacancy letting extra cooling air leak through and preventing combination of all the carbon with oxygen, in defective working, show small but steady smoking at the stacks' top in amount aggregating to that of the other intermitted but imposing smoke cloud so very patent. The waste gases allowed to escape by forced or chimney draft should carry 13 per cent carbonic acid and be at 290 deg. F., the temperature of the steam boiler.

Of especial local interest it is that we have here above the river level, the geologic horizon of the Crinoidal Limestone, midway between the Pittsburg coal above and the Freeport coal below, marking by the fossil remains the ending of the marine old life and the beginning of the fresh-water deposits and organisms. Another change in the plant remains is seen when the rocks 700 feet higher are reached atop the Waynesburg coal seam—of which, however, only a remnant is left in Allegheny County, in Bethel Township—where we first meet in going upward in the series of these sedimentary groups of limestone, fireclay, coal, shale, and sandstone, a modern flora—higher than the ferns, of which 600 species had become extinct in these Paleozoic formations below, which are so defined at their top, and from which their extent of thickness is a mile or two down vertically through Carboniferous, Devonian, and Silurian formation strata.

We are here at the surface as our ground, on the eroded terraces of the Lower Barren division and of the Upper Productive, of the Carboniferous formation.

We believe now that the old ranker vegetation had little directly to do with giving us the store of fossil fuel, the coal beds; but that like the formation of the peat bogs continuing in our day, lowly mosses an inch or two high in quiet growth at the spot, made these coal measures of even thickness so extensive.

[Concluded from SUPPLEMENT No. 1627, page 26006.]

CORN-HARVESTING MACHINERY.*

By C. J. C. ZINTHEO.

ECONOMY OF CORN-HARVESTING MACHINERY.

THE benefits to the farmer of using modern corn-harvesting machinery have been pointed out, but a question as to when these machines are really profitable should also be considered by the successful farmer, viz., how many acres of corn must a man have to harvest each year in order to make it a profitable investment for him to purchase a corn harvester or corn picker?

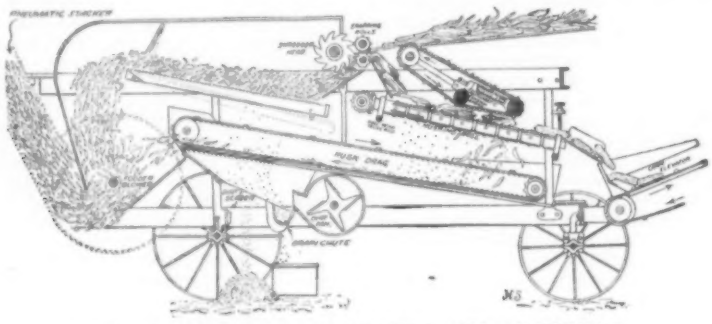


FIG. 19.—SKELETON OF HUSKER AND SHREDDER.

We have found that the average life of the corn binder is 8.17 years, and the cost $125. If a man has only 20 acres of corn to cut per year, the cost for the use of the binder for each year would be $15.30. To this should be added $7.20 for interest, making the total annual cost of the machine $22.50. Other expenses for cutting the 20 acres of corn, according to the previous averages derived, would be $9.20 for team and driver, $6.10 for twine, and $8.96 for shockers; or a total cost for cutting 20 acres of corn with a corn binder of $46.76, or $2.34 per acre. We have seen that the work may be done by hand for $1.50 per acre, and that by hiring a neighbor's team and binder at 75 cents per acre, the work may also be done for $1.50 per acre. We may then conclude that a farmer who has only 20 acres of corn to cut per year and does not intend to cut any for his neighbors would lose money by purchasing a corn binder.

If a farmer has 30 acres of corn to cut per year, the annual cost of the machine, including interest, would be 75 cents per acre. It will require a cut of at least 80 acres per year before the farmer can properly estimate the cost per acre for the use of the machine to be 29 cents, as already given. It may, therefore, be concluded as a general proposition that unless this number of acres is available for cutting each year, the investment in a corn binder is not profitable.

These estimates may not be exactly fair, because if the corn binder cuts but 20 acres per year, the life of the machine would probably be considerably longer than eight years. This would in a large measure depend upon the care the machine received. If left outdoors the wear and tear on the machine when not in use would be more than when used. However, with proper care it would last longer, and there is no doubt that in general half the money which our farmers spend for implements could be saved if they gave their implements better care when in use, and when not in use protected them in an implement shed from wind, rain, sunshine, and farm animals.

In the same way we may determine when it is advisable to use a corn picker. The price of these machines ranges from $200 to $325, but if we take $250 as the average price and the average life of the machine and acreage cut as previously noted, the cost per year for the use of the machine would be $30.59, and interest on the investment would be $15. To this should be added about $5 per year for repairs, or a total of $50.59 per year for the use of the machine. In order to make this machine a profitable investment it should husk at least 87 acres of corn each season. Circumstances may alter cases and different conditions change the problem, but in general it is better not to invest in expensive implements unless there is sufficient work in sight to make them profitable.

HUSKERS AND SHREDDERS.

Simple Husking Devices.

One of the earliest devices used for husking corn was the husking peg. Several patterns of this are in common use. There are also other aids to corn husking made in the form of gloves, with projecting points or pegs. Equipped with such a glove the man passes along the rows, husks the ears by tearing off the husks and snapping the stems, and tosses them into the wagon which is drawn alongside. Such husking pegs and gloves are also used in husking corn from the shock.

Combined Huskers and Shredders.

Up to 1880 no machine had been produced designed to perform more than one operation on the stalks, except some of the unsuccessful and later experimental harvester types designed to pick and husk the ears, as previously described. Between 1880 and 1890 a great deal of attention was given to thrashing corn. This practice so battered the stalk as to make every part of it available as a cattle food. Fodder cutters had been in use for many years, yet this method of preparing corn fodder left the fibrous part of the stalk in a tough, woody condition which the cattle did not much relish. The bruising and shredding action of the thresher put the stalk in a more palatable form. The repeated shortages and failures of the hay crop during the decade 1880-90, together with the results of attempts at threshing corn led to the invention of the combined husker and shredder, which takes the stalks with the ears on them, removes the ears, husks them, and prepares the stalks for feeding. A combined husker and shredder patented by J. F. Hurd, of Minnesota, in 1890, application having been filed in 1887, is one of the earliest of the shredder type.

There are at this time many different makes of this machine in the market. They are of various designs and are frequently made so as to be fitted with exchangeable cutter and shredder heads. The general construction of all machines of this class is very much the same, however. Some are rather complicated in their construction while others are very elementary. A discussion of one of the more complicated will serve to explain the general operation of all. By referring to Fig. 19 the construction will be easily understood.

The stalks are first fed to the snapping rolls, where the ears are broken from them. The stalks are driven forward by the snapping rolls until they meet the shredder head, where they are cut to shreds by knives of special forms shown in Fig. 20. The shredded parts of the stalk fall upon a vibrating carrier whose motion is complemented by the action of arms. The shreds fall from this carrier into the blast from the fodder blower, which carries them up through the stacker.

The ears which are broken from the stalks by the snapping rolls drop upon the husking rolls where the husks are torn from them. The husked ears gradually descend along the inclined husking rolls until they finally fall upon an elevator which carries them to the bin or other place provided for them.

The husks fall upon a conveyor chain which drags them back to the fodder blower, where they join the shreds from the stalk. The loose grain falls from the vibrating carrier and husk conveyor upon a screen. As it falls it is met by a mild blast which removes the dust from it. This grain is then collected in a trough or chute and is driven by means of a screw conveyor to one side of the machine.

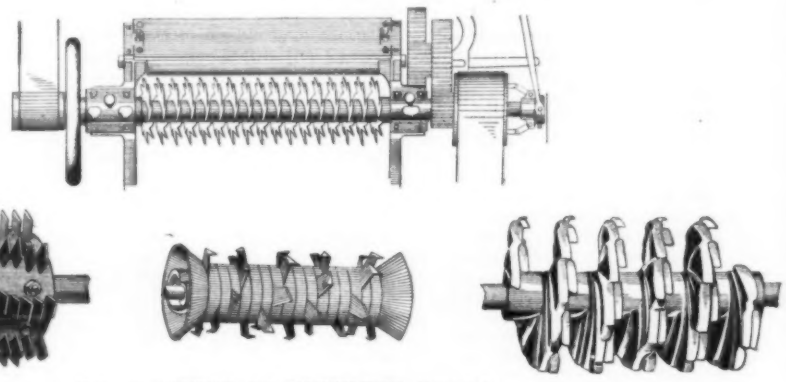


FIG. 20.—FORMS OF SHREDDER HEADS.

FIG. 21.—HUSKER AND SHREDDER RUN BY GASOLINE ENGINE.

This machine combines in its construction many elements used in earlier machines, both huskers and fodder cutters. The snapping rolls and husking pegs are both ideas found in machines described in preceding paragraphs, while the shredder heads are not greatly different from those of the fodder cutters of earlier

* Abstracted from a bulletin issued by the Office of Experiment Stations, United States Department of Agriculture.

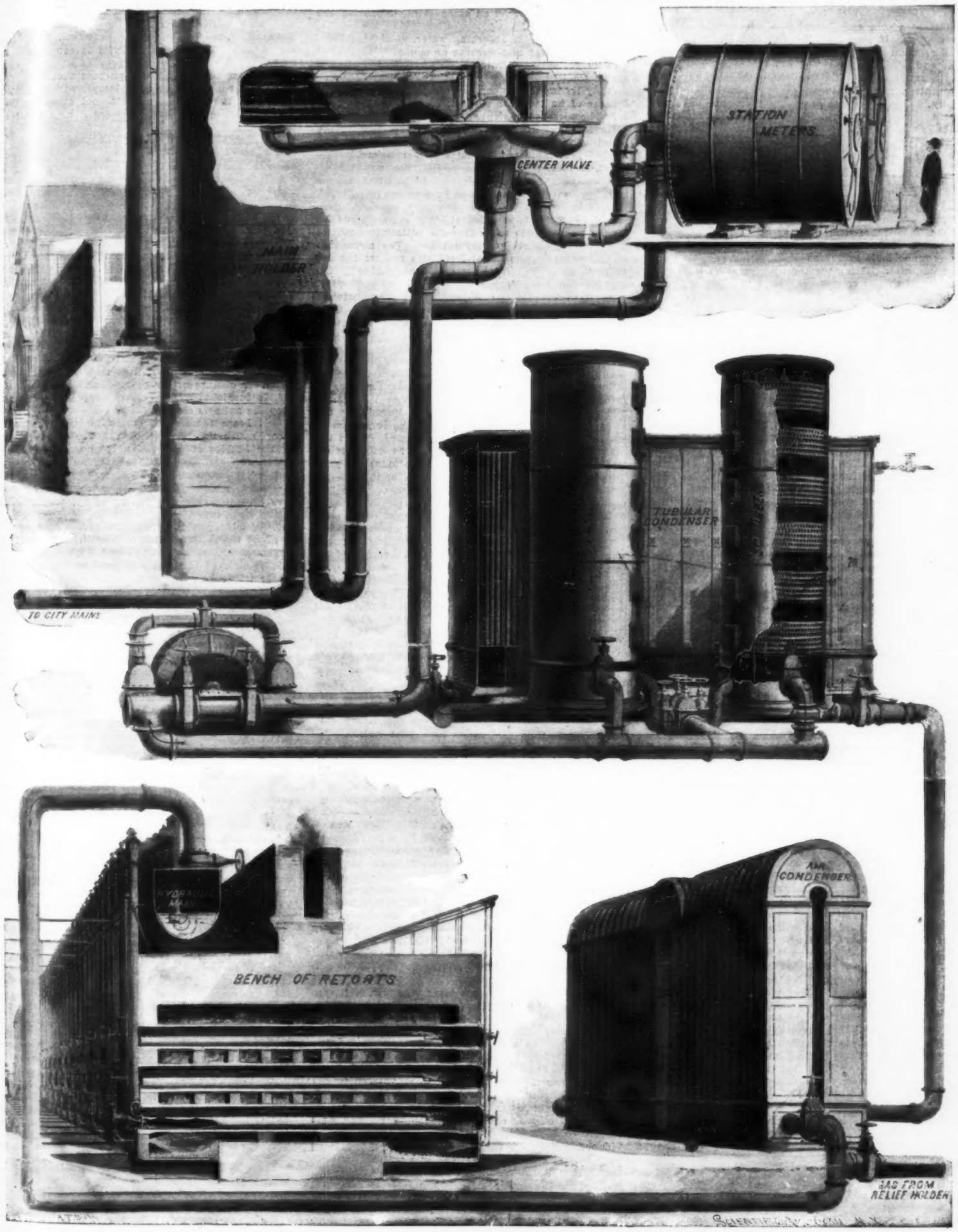
design. The blower and cleaning and carrying devices are very much like those of the thresher. Self-feeding and safety devices are now largely used as a protection against the danger of having one's hand or arm caught in the mechanism. Where the self-feeder is used, a revolving hand cutter is commonly placed a little ahead of the snapping rolls.

MANUFACTURE OF WATER-GAS AT THE FORTY-FOURTH STREET STATION, NEW YORK.—III.

IN our issue of March 9, we described a portion of the Forty-fourth Street plant of the Consolidated Gas Company for the manufacture of water-gas. The article referred to described the Lowe apparatus, in which illuminating water-gas is produced, and also the Gasogene plant, for the manufacture of non-illuminating water-gas. It was shown that the products of these two plants are led to a relief holder, from which they are conducted to the condensers of an oil-gas plant. The oil-gas from this plant and the mixture of illuminating and non-illuminating water-gas, after being combined in these condensers, are passed through the successive stages of scrubbing, purifying, etc., and finally collected in the main gas-holder.

OIL-GAS PLANT.

The first element of the oil-gas plant consists of a row of eighteen benches, containing six retorts, in which the oil and steam are decomposed. Each bench contains six retorts arranged in tiers of three. The retorts are cylindrical in section, and extend entirely from the front to the back of the bench. They are set in fire-brick walls, and the whole of the masonry, including the arches, etc., is built of the best firebrick. The retorts are closed at each end by cast-iron mouth-



THE MANUFACTURE OF WATER-GAS.

The superior convenience of having the stalks bound into bundles is most evident where these machines are used. In bundles the stalks keep straight and thus avoid the delay caused by having them come to the machine in a disordered condition. There is also less danger of choking the machine. Fig. 21 shows a husker and shredder run by a gasoline engine.

pieces provided with movable lids. Each bench of six retorts is heated by two furnaces, one on each side, into which a supply of oil is sprayed under air pressure. The liquid fuel consists chiefly of the tar, pitch and various oils which are collected in drip tanks to which they flow by gravity from the hydraulic mains, the scrubbers and the condensers. From the drip tanks the refuse oil is pumped to a general collecting tank, from which it flows to the burners at the retorts. Within each retort is a 6-inch, wrought-iron pipe, which is closed at one end and has a semi-circular section cut away from the upper half of the opposite end. To the closed end of each of these pipes is led a small supply pipe, by which the oil and steam are introduced. The mixture is vaporized and partially decomposed within the pipe, and the resulting gases, escaping from the opposite end of the pipe, flow back above it to finally leave the retort by means of a vertical standpipe. Our sectional view, taken through one tier of retorts, shows the front of the retorts with the long line of standpipes extending above it. The gases pass from the standpipes down into the hydraulic main, where the tar and heavy oils are condensed and collected. The standpipes terminate in what are known as dip pipes, which are carried down a few inches below the surface of tar and liquor, as shown in the engraving. The liquor is maintained at a predetermined level by means of an adjustable gate, and the gas, after passing through the liquor, is led to the bottom of the air condensers. Here it is joined by the mixed gases from the relief holder, already referred to. In passing through the retorts, the oil is decomposed into a fixed oil-gas which is practically the same as the Pintsch gas so largely used for the lighting of street and railway cars. The gas mains which lead from the relief holder and from the oil-gas retorts are provided with gates, which enable the operator to mix the two gases in the proper proportions to give an illuminating gas of the desired candle power. The air condenser consists of two wrought-iron bases, each section of which is 6 feet wide and 30 feet in length. From the base there extends a series of vertical rectangular sheet-steel pipes, each pair of which is connected by a bend at the top. The pipes are so arranged as to operate in sections of four, the route followed by the gases in passing through the condenser being such that a given volume, in passing from one end to the other, has to travel through a linear distance of 500 feet, and is exposed to a total cooling surface of 15,000 square feet. Here the gases are cooled from a temperature of 180 deg. to one of approximately 100 deg., the temperature of the issuing gases varying, of course, according to the temperature of the atmosphere and the amount of gas that passes through in a given time. In the process of cooling, any oil which may not have been thoroughly fixed in the retorts is deposited, and falls to the base, from which it drains off to a drip tank.

From the outlet of the condenser the mixed and cooled gas is led to the base of a tubular water condenser, where it passes up and down through a series of tubes that are surrounded with circulating water. Here the gas is cooled down to a temperature of 80 deg. F., and any unfixed oils that may remain are deposited. From the condensers the gas passes to the scrubbers, which are constructed on the same general principles as those already described, the cylinders in this case being divided by a vertical diaphragm, whose object is to cause the gases to travel up through one-half of the condenser and down through the other half. In these condensers care is taken to use only a limited amount of water on the already cooled gases, as an excessive amount would be liable to absorb a certain portion of the illuminants. The gas is drawn from the scrubbers by the suction of a powerful centrifugal exhauster, and forced through a big valve known as the center valve, from which there radiates a series of horizontal pipes, which lead to the base of the purifiers. The purifiers are large cast-iron boxes measuring 24 feet square and about 4 feet in depth. Each box is provided with a wrought-ifon cover, which, when it is in place, is seated in a water seal that renders the purifier gas-tight. The interior of each of these huge boxes contains two sets of gratings or grids, upon which is thickly strewn a purifying material, which consists of wooden chips and shavings that have been thoroughly saturated in oxide of iron. The gas filters up through this material, and the action of the oxide of iron serves to remove the remaining impurities, which consist chiefly of sulphur in the form of sulphureted hydrogen. From the purifier the gas passes to two large station meters, where it is measured, and a record obtained of the actual amount that is being manufactured hour by hour. From the meters the gas is led to a large gas-holder, with a capacity of 2,000,000 cubic feet, and from the gas-holder it passes, under a pressure of from 3 to 7 inches of water, to the city mains.

Although the Forty-fourth Street station has a capacity of 8,000,000 cubic feet per day, it requires only an area of slightly over two acres to accommodate the plant, a fact which is favorably commented upon by the many foreign experts who have at various times visited the station.

Spotted Metal Coloring.—To produce spotted metal finish, the articles, according to a process patented by Kollof and Bautje, of Berlin, are first silver-plated and then slightly coppered. Then a layer of copper sulphide is produced by the action of sulphur or an alkaline sulphide solution; this is afterward removed in places to allow the silver to show through.

[Concluded from SUPPLEMENT No. 1627, page 26063.]

THE TECHNOLOGY AND USES OF PEAT.*

By C. W. PARMELEE.

USES IN AGRICULTURE.

THE agricultural status of peat of forty or fifty years ago is best given by Dr. S. W. Johnston. According to him, the usefulness of the raw peat depends upon two things: 1. As an amendment, improving the texture of the soil.

a. By its power of absorbing water.

b. By its power of absorbing ammonia.

c. By promoting disintegration and solution of mineral ingredients.

d. By its influence upon the temperature of the soil because of its moisture content.

2. The nitrogen content.

Modern practice, however, would refrain from the direct application of peat to arable soils. It is considered preferable to compost the peat before its application to the land. Occasionally, however, the direct use of peat on the soil may be justified, as, for instance, under circumstances mentioned by Storer, that is to say, on land in a limestone country. Generally, for direct application, it must be weathered for some time in order to destroy its antiseptic qualities and break down its gummy texture. The abundance of concentrated commercial fertilizers renders the use of peat, as it was formerly employed, decidedly unprofitable in most localities.

As a Filler.—Of late a number of manufactories have been established for the purpose of preparing peat powder for use as a filler in commercial fertilizers and for mixing with dried blood. This use of peat is quite legitimate for it enables the manufacturers to produce a fertilizer of superior mechanical condition. Fertilizers, and especially those made up of hygroscopic materials, show a strong tendency to form lumps. Under such circumstances it becomes difficult to distribute the fertilizer uniformly on the soil. Where peat is used as a filler, the formation of crusts or lumps is more readily prevented. From the consumer's standpoint, the use of peat as a filler is objectionable when the manufacturer includes the peat nitrogen in his guarantee and charges for it the same price paid for high-grade organic nitrogen. Peat furnishes an especially tempting material to use because of the fact that nitrogen is almost always found present. Dr. S. W. Johnston found in the examination of 30 samples from Connecticut that there was a variation from 0.4 to 2.9 per cent, with an average of 1.5 per cent. In our examination of 123 samples from this State, all contained some nitrogen. The lowest was 0.74 per cent; the highest was 2.83 per cent. The average is 1.75 per cent. The nitrogen of peat, when the latter is directly applied to the soil, yields but slowly to the various agencies of decay, so that it is clear that its value as a source of food to plants is quite limited. A number of authorities, among them Stutzer, go so far as to deny any value whatever to peat nitrogen when so used. Storer, on the other hand, is inclined to think that a portion of the peat nitrogen may become available within a year. He says:[22] "Generally speaking by far the larger part of the nitrogen in peat exists in a form which is insoluble in water and comparatively inert, considered as a plant food. In spite of its inertness, it is a matter of familiar observation and experience that the peat nitrogen may be made to contribute to the support of crops, and that it has consequently a considerable money value." According to Nessler,[23] "although the nitrogenous constituents of peat decompose in the soil more slowly than the altered ossein in meal from steamed bones, they do, nevertheless, in some cases decompose more quickly than the nitrogenous component of wool, or than the ossein in coarse meal from raw bones, or than those in leather meal, either that or from torrified leather." Summing it up, it appears that it is neither better nor worse than many other low-grade nitrogenous materials now freely used by the manufacturers of fertilizers. There are three factories in this State located on Great Meadows, Warren County, engaged in preparing peat for filler in fertilizers.

As a Litter.—The surface layer of many bogs consists of the fibrous remains of the vegetation which has grown there. When this material is of a suitable nature and of sufficient thickness it is frequently prepared for use as a litter for stables or as a packing material, and for many other purposes for which a soft, elastic, absorbent, fibrous material may be used. It is a general practice in Germany, Holland, and other peat-producing countries to combine the manufacture of peat litter with the preparation of peat fuel, if both kinds are found in the same bog. According to the official report of the Hannoverian and Oldenburg Railroad administration, about 21,873 tons were sent from stations on that road during the year 1882. This country imports a considerable quantity for use in the stables of large industrial establishments. It sells in New York for $10 to $16 per ton. There is only one factory in this country engaged in the manufacture of this product. This is located at Garret, Ind. The litter is sold at $1.40 per bale of 225 pounds. A considerable quantity of the peat moss is cut by florists and nurserymen for their own use from convenient bogs, and some is shipped from New Jersey to the nearby cities for the same purpose.

The peat is cut in sods with spades in the same manner as already described. The best time for cutting is in the fall or early winter in order that the freezing may assist in disintegrating the lumps and leave the fiber loose and elastic. In northwest Germany the bog is plowed and harrowed in the fall, after first removing the top growth by burning. Another harrowing is done in the spring. After the peat has been sufficiently dried in the air it is shredded in a machine called a "wolf." This contains a drum covered with teeth, which tear the fiber asunder. The fine stuff, sieved out and called peat mull, has a number of uses. The fibrous material is compressed and baled.

Peat moss suitable for this purpose should be loose, without hard, earthy or solid lumps, with a moisture content in the air-dried material not exceeding 20 to 30 per cent, and it should possess a high absorptive power.

The largest present use of the product which we call peat litter is in the stable. Its value depends upon the following properties:

1. It is highly absorbent. A good litter will absorb eight times its own weight of urine, whereas straw will absorb only three times. Wollny,[24] in a comparative study of equal volumes of different litters, found that peat stood first, rye straw fifth.

2. Peat litter not only prevents the waste, but also conserves the value of the urine and excrement by either preventing decomposition or by retaining the ammonia set free. Prof. Fleischer is quoted as saying that by the use of such litter in a stable of ten head of cattle, soluble nitrates to the value of $35 would be retained, which would be lost with straw. The portions of the liquor which are not absorbed have been found to contain less solubles than the original.

3. By reason of its own nitrogen content plus that from the excrement, the litter makes a superior material for manure or for composting.

4. It furnishes a soft, elastic, dry bed, which will keep the animals clean.

5. It keeps the feet of horses in better order, and according to the "Report on the Use of Moss Litter by the Stables of a Prussian Regiment of Uhlans,"[25] "catarrh of the nose and eyes, generally the result of bad air in the stables, is less frequent. Wounds on the legs heal more quickly, inflammation of the glands very seldom occurs and rotting of the frog is almost entirely prevented."

6. Less litter is required than in the case of straw in about the ratio of 1 ton of peat litter equals 2 tons of straw.

7. The air of the stable is kept sweeter. There is less moisture, and leather trappings remain in a better condition.

TEXTILES.

Repeated efforts have been made to utilize a particular kind of a fibrous peat as a raw material in the textile industries. For this purpose the so-called wool-grass is best suited. This growth, the *Eriphorum vaginatum*, is only occasionally found, and then sometimes at a little depth below the surface. There is no question of the possibility of preparing a soft, flexible, bleachable fiber which will dye well, but of the many methods which have been advanced it does not appear that any have been able to produce a fiber at a sufficiently low cost. A practical demonstration of the application of this fiber in the arts was made at the Vienna Exposition of 1898, where a building was furnished with carpets and curtains made from this material. Further, at one time the French government was supplied with mattresses, saddle cloths, and blankets of this fiber.

When prepared for surgical uses it is said to have the considerable advantage of possessing a very high absorptive power, which is more gradual than cotton, besides being cheaper and possessing antiseptic properties. According to a writer in the London Lancet,[26] "when peat dressings were used, serum and blood were all absorbed, and even after many days the peat thus soaked was perfectly free from decomposition."

Peat fiber has been suggested as a substitute for cotton waste for oiling machinery.

Attempts to use peat fiber as a paper stock have met with similar difficulties as in its use in fabrics. It has to compete with very cheap raw materials, such as straw and wood. It is troublesome to clean of its dirt, it is difficult to bleach, and requires the addition of fiber from old bagging, ropes, etc. A factory for the manufacture of cardboard has recently been established at Capac, Mich., and is now producing experimentally. The product contains 10 per cent wood fiber. It is not bleached, but is of a brown color.

Fibrous peat is highly recommended as a packing material because it is elastic and highly absorptive. The latter property is of advantage in packing breakable containers holding liquids.

AN ABSORBENT.

The highly absorbent power of peat in the form of litter has already been mentioned. The powder or mull which separates from the litter during the process of the manufacture of litter possesses this same property in the same high degree. It has a general use in Europe as an absorbing, deodorizing, and disinfecting material for privy vaults. During the cholera epidemic in Hamburg, Germany, in 1892, the use of the mull was made compulsory in the city of Christiania, Norway.

The charred peat powder is said to have been on the market in this country for a number of years as a deodorizing powder.

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* Abstracted from the Annual Report of the State Geologist of New Jersey.

[22] Agriculture, New York, 1897, vol. iii., p. 79.

[23] Storer, Agriculture, New York, 1897, vol. ii., p. 85.

[24] Storer, Agriculture, p. 278.

[25] Journal of the Royal Agricultural Society, 1893, p. 763.

[26] United States Consular Report, 1892-93.

Owing to the properties mentioned, the mull is an excellent material for packing, especially for perishable articles. It is also recommended for propagating beds either for seedlings or for mushrooms, because it retains its moisture for a long time, and retards putrefaction. Plants may be protected against frost by its use without danger of rust or mildew. Since peat litter is recommended for use in fowl houses because of its deodorizing properties and its power of banishing vermin, it appears that the powder would be equally efficient.

The powder treated with carbolic acid and iodoform has been filled into bags and used for surgical purposes.

It has also been used to absorb the waste molasses of the sugar refineries and the product fed to cattle. Or the mass may be used for a fertilizer, enriched as it is by the presence of a considerable quantity of mineral salts, notably the salts of potassium. Twenty-five parts of the powder will take up one hundred parts of liquor and still be in an easily transportable condition.[37]

The powder has also been used as a filtering medium for oil.

A NON-CONDUCTOR OF HEAT AND SOUND.

The fiber or powder may be used advantageously as a filling between walls wherever sawdust is used, as ice-houses, etc., or between the walls of telephone booths.

A PRESERVATIVE.

This power of peat has been frequently demonstrated in many strange ways. For example, in the year 1830 two human bodies were found in a moor near Halfsleben, Thuringia, who, according to the dress and gold ornaments, must have lived at the time of Julius Cæsar. The flesh and hair were well preserved. In the year 1747, in Lincolnshire, England, the body of a woman was found in a bog at a depth of seven feet. The only change that the flesh had suffered was a brownish discoloration. The sandals on her feet and her clothing bore unmistakable evidence of the centuries that had passed since her body had sunk into the bog. This preservative power in a living moor has been ascribed to the protection from the action of atmospheric oxygen and the presence of humic acid. This interesting property has been utilized in a practical way. Perishable articles, such as fish and fruits, have been packed in peat and sent on long journeys, and after many days, upon arriving at the destination, they have been found in a perfect condition. It is said that potatoes so packed will not sprout.

MISCELLANEOUS USES.

A great number of uses other than those mentioned have been proposed which are interesting, but of little importance. Other and cheaper raw materials are at hand. Among the proposed uses we find the manufacture of alcohol. The process suggested is that of treating the material with sulphuric acid and fermenting the sugar formed and distilling off the spirits. A yield of 62 to 63 liters of alcohol is claimed for 1,000 kilogrammes of peat.

An Austrian inventor proposes to use the fiber in the manufacture of paving material.[38] It is claimed that the artificial wood hardens steadily in moist soil and is well suited for sleepers, holding screws and nails well, and resisting rotting.

A brown dyestuff may also be separated from peat in the process of the manufacture of paper.

[Continued from SUPPLEMENT No. 1622, page 25091.]

SOLDERS.—III.

GOLD SOLDERS.

GOLD, both pure and variously alloyed, is used to a considerable extent in soldering, but on account of its expensiveness it is limited to articles made of gold or platinum, or the most delicate small steel objects.

Gold alloys are of different colors, according to the kind and proportion of the other metals used. There are yellow, red, white, and green gold alloys. The color of the special alloy should of course be in harmony with the color of the object to be soldered, in order that the seams may be as inconspicuous as possible.

The fusibility of gold alloys varies as much as their color, and is lowered as the amount of gold in the alloy increases. Harder solders should therefore be used for objects of fine gold than for a poorer quality.

Gold solders are made from gold and silver, gold and copper, still more frequently from a mixture of all three of these metals; in some cases zinc is added, to make the solder softer. But this must not be done if the soldered articles are to be colored, as the zinc alloy will turn black in coloring. For objects which are to be wholly or partially enameled, the solders made of gold and silver, or of gold, silver, and copper, are the only ones used, and these are called "enamel solders."

Pure Gold Solder.—Before soldering apparatus had been devised by means of which platinum could be melted, pure gold was used for soldering articles made of this metal, such as are employed by chemists and in the manufacture of sulphuric acid. For this purpose, the gold is laid upon the seams in the form of fine rolled wire, or in thin strips, and melted with the oxy-hydrogen blowpipe. But experience has shown that platinum articles soldered with gold are far less durable than those made by direct melting together of the pieces of platinum with the blowpipe, especially in the case of the vessels used in distilling the English sulphuric acid. Of late years this process has become universal in the manufacture of platinum ware, and the gold is only used for repairing small platinum articles, such as the small crucibles and dishes for chemical laboratories. It requires a fierce white heat to melt it properly, and it is even then rather hard, so that the process of soldering demands great skill on the part of the workman.

Hard Gold Solder.—

Gold 750/1000 fine (18 carat)	9
Silver	2
Copper	1

This is used for the finest gold articles.

Soft Gold Solder.—

Gold 750/1000 fine (18 carat)	12
Silver	7
Copper	3

This is likewise used for fine gold, but is much more fusible than the one first given.

Gold Solder for Articles 583/1000 fine (14 carat).—

I.

Gold 583/1000 fine (14 carat)	3
Silver	2
Copper	1

II.

Gold 583/1000 fine (14 carat)	4
Silver	1
Copper	1

Gold Solder for Ordinary Gold Ware less than 583/1000 fine (14 carat).—

I.

Fine gold	1
Silver	2
Copper	1

II.

Fine gold	1
Copper or silver	2

Soft Gold Solder.—

I.

Fine gold	11.94
Silver	54.74
Copper	28.17
Zinc	5.01

II.

Gold 583/1000 fine (14 carat)	10
Silver	5
Zinc	1

Enamel Solder, Hard.—

Gold 750/1000 fine (18 carat)	37
Silver	9

Enamel Solder, Soft.—

Gold 750/1000 fine (18 carat)	16
Silver	3
Copper	1

The degree of fusibility of the enamel must decide the question as to which one of these compositions to use. If it is very hard, the first solder is the proper one, as otherwise the seams would become so hot during the process of melting the enamel that the solder itself would melt. For ordinary gold ware soft enamels are generally used, and in this case the softer solder can be employed. It is easily melted with the common soldering pipe; the harder can also be melted in the same way, but the use of a special apparatus makes the process much easier and quicker.

ALUMINIUM SOLDERS.

Since the discovery of aluminium and its production in considerable quantities, it has become a common material in the manufacture of various artistic objects. One of the greatest difficulties, however, in the past, has been that there was no perfect solder for aluminium, and various alloys were used which gave unsatisfactory results. This difficulty has now been overcome, and it is possible to solder the metal so perfectly that in tests which have been made the metal itself broke before the solder gave way.

The French manufacturers use five kinds of solder for aluminium, all consisting of zinc, copper and aluminium, in different proportions. These are given below.

I.

	Parts by weight.
Zinc	80
Copper	8
Aluminium	12

II.

	Parts by weight.
Zinc	85
Copper	6
Aluminium	9

III.

	Parts by weight.
Zinc	88
Copper	5
Aluminium	7

IV.

	Parts by weight.
Zinc	90
Copper	4
Aluminium	6

V.

	Parts by weight.
Zinc	94
Copper	2
Aluminium	4

There are also other compositions besides these. Bourbouze recommends, for objects which are to be further manipulated or worked on after soldering, a mixture of 45 parts of tin and 10 of aluminium.

Frischmuth gives the following alloys for solders:

	A.	B.
Silver	10	....
Copper	10	....
Aluminium	20	....
Tin	60	95 to 99
Zinc	30	....
Bismuth	..	5 to 8

The composition B (an ordinary soft solder) is for soldering aluminium by means of the common soldering iron.

In preparing aluminium solders, the alloy of copper and aluminium is always made first, and the zinc added. First of all the copper is melted, and the aluminium put in gradually, usually in three or four portions. The two metals are of very different density, and the mixture should be stirred with an iron rod, to unite them as far as possible. Immediately after adding the last portion of the aluminium, the zinc is put in, and at the same time some fat or resin is thrown into the kettle, the whole is quickly stirred, the kettle removed from the fire, and the alloy poured into iron molds which have been rubbed with coal oil or benzine. The whole work must be done as quickly as possible after the addition of the zinc, or the solder will not remain in a suitable condition.

The zinc used should contain no iron, as a very small amount of the latter would materially affect the fusibility and durability of the solder. The purpose of the fat or resin is to prevent the oxidation of the zinc, and, as before observed, the work must proceed as rapidly as possible from this moment, as the temperature of the mass is so high that if it were left long in fusion much of the zinc would evaporate.

On account of its resistance to chemical influences, aluminium solder is frequently used by dentists to unite the metallic parts of artificial teeth, but alloys for this purpose must not contain copper except in very small quantities, as this metal is easily attacked by acids.

Platinum and Aluminium Solder.—

Gold	30
Platinum	1
Silver	20
Aluminium	100

Aluminium and Gold Solder.—

Gold	50
Silver	10
Copper	10
Aluminium	20

Solder for Aluminium Bronze.—Aluminium and copper make a very beautiful alloy, and one of valuable properties, much used for soldering artistic objects. Aluminium bronze demands a special composition, and for this purpose a common soft (white) solder is generally used, mixed with zinc amalgam in different proportions, either 2, 4, or 8 parts of the solder to 1 of the amalgam. Zinc amalgam is an alloy of zinc and mercury, as evident from its name (amalgam) being the general designation for alloys of mercury with other metals. To prepare it, 2 parts of zinc and 1 of mercury are united, with heat. The zinc is melted, the mercury quickly stirred in and the mixture quickly cooled. It is a somewhat brittle alloy, silver white in color. To make the solder for aluminium bronze, the soft solder is melted, the zinc amalgam, finely powdered, added, and the mass at once poured out into molds.

The soldering must be done with a soldering tool made of pure aluminium; the solder would easily enough adhere, to be sure, to other metals, but would alloy itself with them, and its composition would be changed.

In using the five aluminium solders given above, the kind of soldering to be done must be taken into consideration; for small ornamental objects, for instance, No. 1 may be used; for larger articles, such as teapots, coffee pots, etc., No. 4 is most frequently employed.

Originally the solders composed of aluminium and zinc were the only ones used for aluminium articles; large objects were first put together with an easily fusible solder, and the soldering finished with a harder one. The alloys of aluminium and zinc have the disadvantage that they oxidize easily in melting, and the work is made much more difficult thereby. This can be remedied by dipping the fine grains of the solder (in which form it is used) in copaiva balsam, which acts as a reducing agent, besides excluding the air. But this is not necessary if the compositions containing copper are employed.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Edmund Schlosser's "Das Löten und die Bearbeitung der Metalle."

LLOYD'S SHIPPING RETURNS.

THE return of vessels totally lost, condemned, or otherwise removed from Lloyd's Register for the quarter ending September 30 last has just been published. The total number of vessels thus disposed of was 143, aggregating 110,605 gross tons. Of this total, 54, aggregating 54,988 gross tons, were steamers, the remainder being sailing craft. The losses by collision were six steamers and five sailing ships, and by wreck 35 steamers and 47 sailing craft. One steamer and four sailing vessels were burned, and one steamer and 13 sailers abandoned at sea. The return also shows the nationality of the different craft in existence and the tonnage owned by each country. The British Empire, of course, stands first in the aggregate tonnage with a total of 11,411 vessels, aggregating 17,611,099 tons, of which 9,261 vessels, aggregating 16,166,746 tons, are steamers, and 2,150, aggregating 1,444,348 tons, are sailing ships. In steam tonnage Germany

[37] Thenius, Verwertung des Torfes, Vienna, 1904, p. 222.
[38] United States Consular Report, 66:248, p. 50.

stands second, with 1,628 ships, aggregating 3,375,743 tons; the United States being third, with 1,063 vessels, of 1,431,095 gross tonnage; but this figure does not include the vessels employed on the Great Lakes. In sail tonnage the United States stands second, with 2,048 vessels, aggregating 1,291,444 tons, or very nearly as much as the sail tonnage of the British Empire. Of the total tonnage lost during the quarter, twenty-six vessels, of 31,415 tons total, were steel; thirty-five vessels, of 36,481 tons, iron; while eighty-two vessels, aggregating 41,709 tons, were wood and composite. These figures show pretty clearly that the mortality is greatest among the older and smaller craft, as would naturally be anticipated.

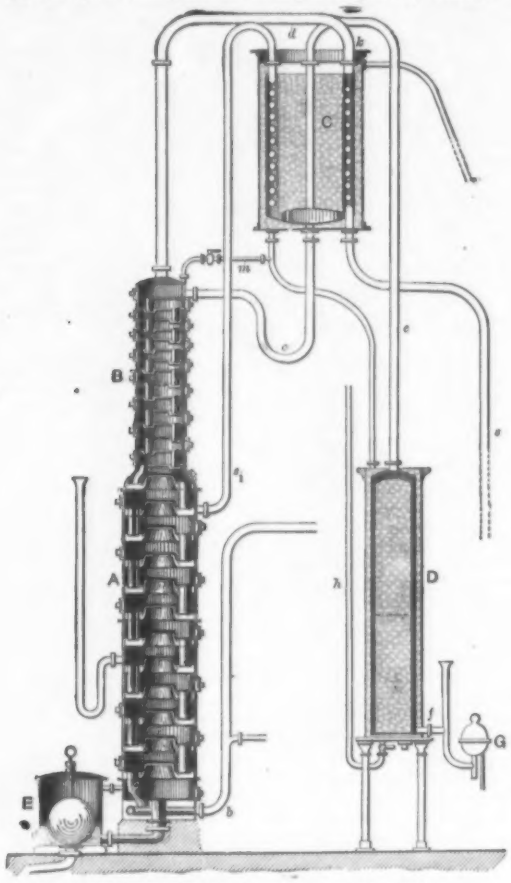


Fig. 13.—GENERAL TYPE OF COLUMN APPARATUS.

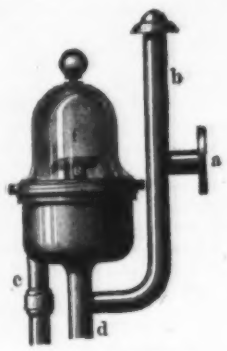


Fig. 14.—SPIRIT OUTLET.

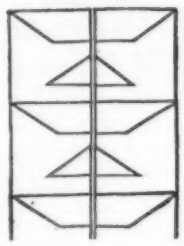


Fig. 17.—ILGES PLATES (SIDE VIEW).

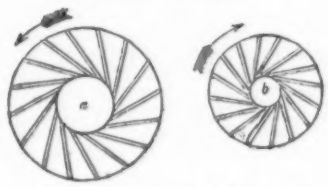


Fig. 18.—ILGES PLATES (PLAN).

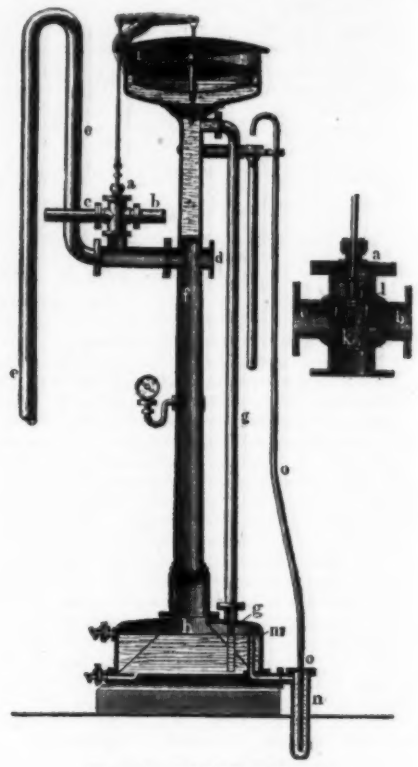


Fig. 19.—ILGES STEAM REGULATOR.

[Concluded from Supplement No. 1627, page 26074.]

THE DISTILLATION AND RECTIFICATION OF ALCOHOL.*

In Germany the advantages of continuous distillation were recognized early enough, but any attempt to introduce it appeared hopeless because of the peculiar character of potato mash, which contained not only all the undissolved parts of the potatoes, not always finely divided, but also foreign bodies, like stones, straw, and twigs, whose presence, due to imperfect washing of the potatoes, made impossible an uninterrupted flow of the mash through the apparatus. Yet such attempts were made, and the methods of washing and breaking up the potatoes having been improved, the excellent results obtained with German apparatus for continuous distillation of thick mashes have long been generally recognized.

It was, of course, impossible to use French and English apparatus designed for thin and limpid worts. On the other hand, there was at first a natural reluctance to abandon the approved devices for continuous distillation, so these were modified to fit them for the new use. Thus was evolved, from French and German elements, an apparatus for the continuous distillation of concentrated mash, of which the most widely used form is illustrated in Fig. 13. The distilling column is that of Champonnois, the rectifying column that of Coffey (Fig. 12). The mash is pumped, as in Coffey's system, through a spiral tube surrounded by the alcoholic vapor which thus undergoes dephlegmation as it warms the mash. But as, in view of the thickness and sluggishness of the mash, this tube could not have the great length of Coffey's, a shorter worm was adopted and placed in a special vessel called, not very happily, the "condensator" or concentrator, in which the necessary additional dephlegmation was produced by cylindrical vessels filled with water. The spirit condenser was usually of the favorite Gedda type.

Apparatus for continuous distillation of this particular character is generally called column apparatus, and often the Lavalle column apparatus, although it has nothing in common with Lavalle's apparatus except the column with perforated plates which was invented by Coffey at least twenty-five years before Lavalle imitated it. It should, therefore, be called Coffey's column.

We shall now give a detailed explanation of the tower apparatus and then describe some more recent forms, designed for continuous distillation from concentrated mash, which present certain peculiarities and are more or less extensively used.

a. The ordinary German apparatus for continuous distillation of concentrated mash evolved from the column apparatus of Champonnois and Coffey.

By far the most widely employed continuous apparatus is illustrated by Fig. 13, which shows the principle of the apparatus as it is constructed by numerous German makers. It comprises the distilling column *A*, the rectifying column *B*, the concentrator *C*, the spirit condenser *D*, the wash collector *E*, and the spirit outlet *G*.

I. The Course of the Mash.—The fermented mash is forced by a steam pump through the pipe *s* to the concentrator and mash warmer *C*. Here it traverses a worm contained in a vessel with double walls, where it is heated by the alcoholic vapor which enters through the pipe *d*. The hot mash then flows through *s*, to the uppermost of the eleven chambers of the dis-

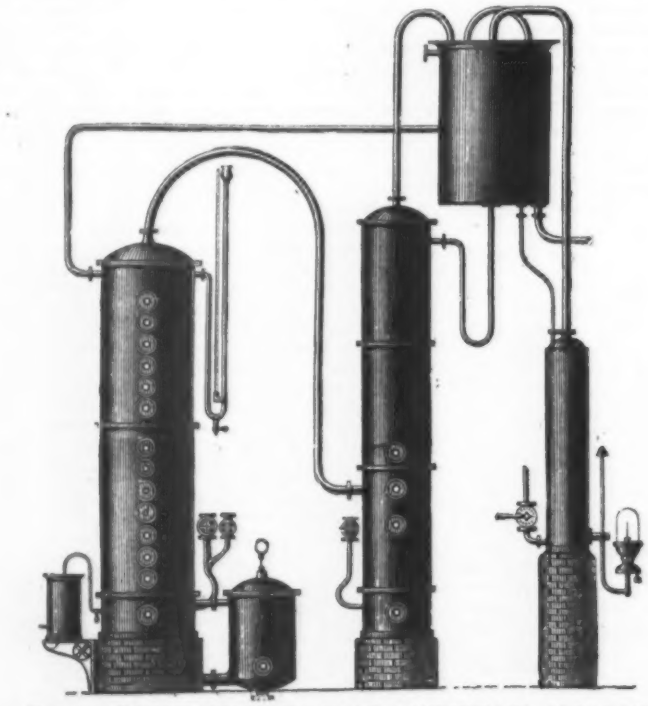


Fig. 15.—PAULMANN'S TWO-PART CONTINUOUS APPARATUS.

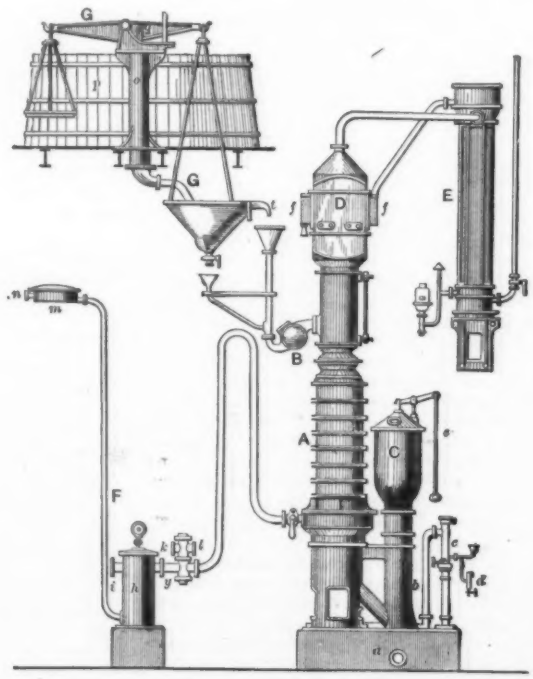


Fig. 16.—ILGES AUTOMATIC DISTILLING APPARATUS.

* Translated from Maercker's "Spiritusfabrikation."

tilling column *A*, where it is again heated by exhaust steam coming from the mash pump. Each of the distilling chambers has an overflow pipe, of which the top is raised above the floor of the chamber and the bottom is lower than the top of the overflow pipe of the chamber next below. The overflow of the second chamber is diametrically opposite that of the first, and so on. The entering mash fills the first chamber to the top of the overflow pipe, overflows through this into the second chamber, which it fills to the top of its overflow, thus closing the bottom of the pipe through which it has descended, and so continues to fill all the chambers down to the wash collector *E*. In this course the mash is compelled by the relative positions of the overflows to traverse the longest possible path in each chamber, flowing around the central vapor pipe and being thoroughly heated by the ascending vapor. The wash collector *E* has a valve controlled by a ball float and empties automatically when the wash reaches a certain level.

II. The Course of the Vapors.—Exhaust or live steam is admitted, as required, through the ring-shaped perforated steam pipe *b*, to the bottom chamber of the distilling column *A*. Thence, it rises into the chamber above, where it necessarily passes in bubbles through the layer of mash because the rim of the cap which surmounts the short communicating pipe is lower than the mash overflow. In this way the steam rises from chamber to chamber, continually enriching itself with vapor of alcohol and continually encountering stronger layers of mash, from the lowest, which is quite exhausted of alcohol, to the highest, which has its original strength.

From the top of the distilling column the now alcoholic vapor passes into the rectifying column *B*, which contains about fifteen chambers with perforated floors

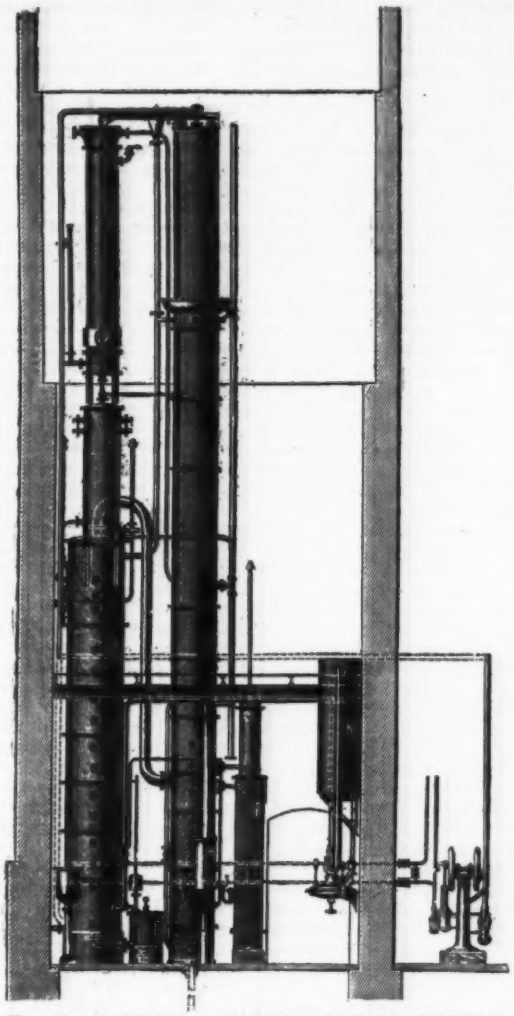


FIG. 20.—PAMPE'S LOW-PRESSURE DISTILLING APPARATUS.

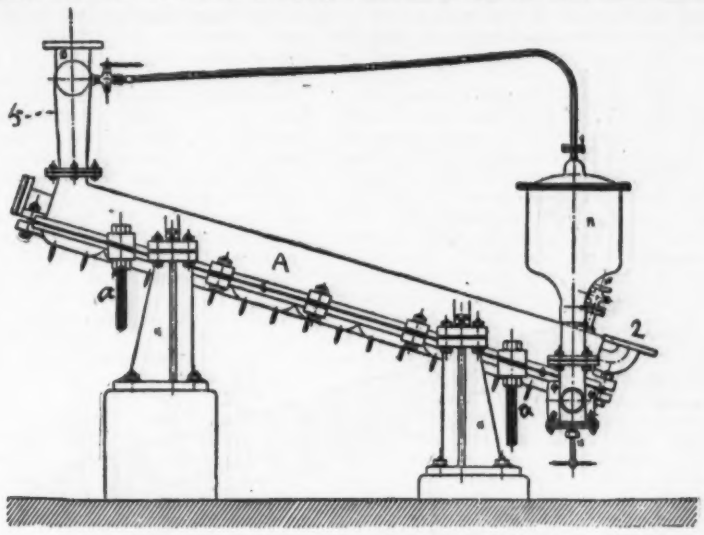


FIG. 22.—GUILLAUME INCLINED DISTILLING COLUMN.

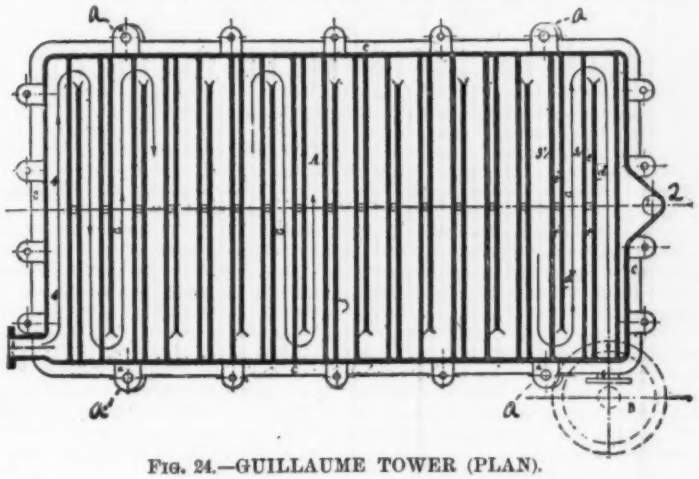
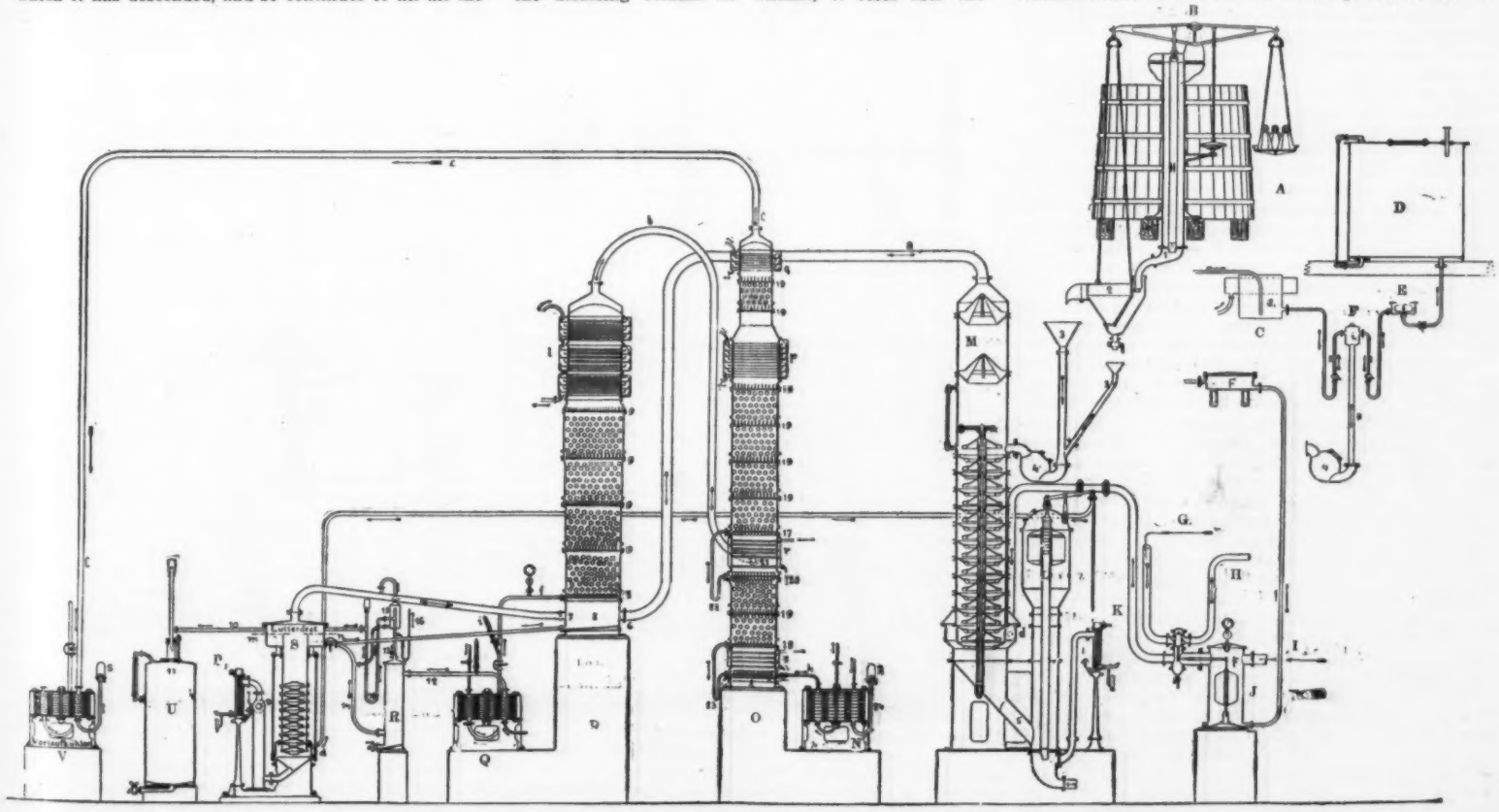


FIG. 24.—GUILLAUME TOWER (PLAN).



A, Mash container; B, mash regulator; C, warm water container; D, raw spirit container; E, regulator; F, mixing vessel; G, boiler steam pipe; H, superfluous engine steam pipe; I, engine exhaust steam pipe; J, steam regulator; K, spent wash test still; L, spent wash regulator; M, mash distilling column; N, spirit cooler; O, second rectifying column; P, first rectifying column; Q, low-wine cooler; R, fusel oil separator; S, low-wine distilling column; T, low-wine test still; U, fusel oil container; V, foreshot cooler.

FIG. 21.—ILGES AUTOMATIC DISTILLING AND RECTIFYING APPARATUS FOR THE PRODUCTION OF REFINED SPIRIT DIRECTLY FROM MASH OF ANY KIND OR FROM CRUDE SPIRIT.

and overflow pipes, and thence into the concentrator *C*. The concentrator consists of a cylindrical water vessel containing a double-walled vessel of annular section, *K*, in which the vapor flows around the coils of the mash worm *s*, which was described above. Part of the vapor condenses on the worm and the walls of the vessel *K* and the remainder escapes through the pipe

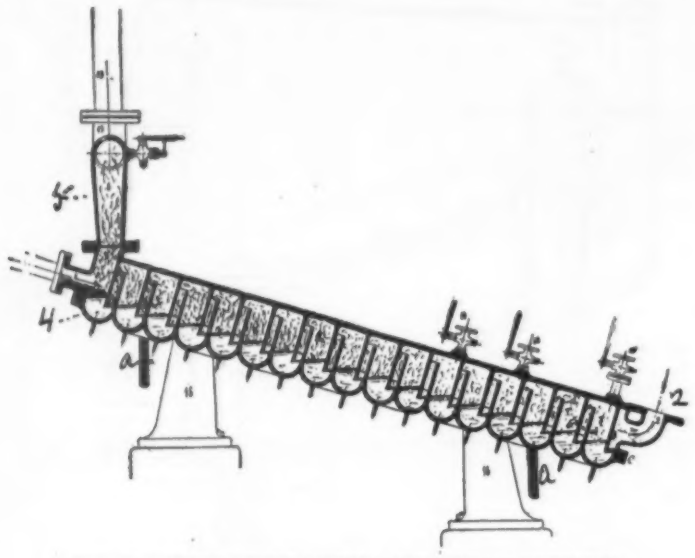


FIG. 23.—GUILLAUME TOWER (VERTICAL SECTION).

c to the spirit condenser *D*. The spirit outlet *G* is shown enlarged in Fig. 14. The spirit enters at *a*, rises in *d*, and, after being tested by an alcoholometer, overflows at *e* into the pipe *c*. *b* is an escape pipe for inflammable gases and should be carried to the open air.

The liquid condensed in the concentrator flows through *c* to the top of the rectifying column *B*, where it descends from chamber to chamber through the overflow pipes, giving up its alcohol to the vapor which rises from *A* through the perforated floors of the chambers. In this form of apparatus this liquid from the rectifying column, the so-called "low wine," which contains fusel oil and other pungent and strong-smelling substances, flows back into the mash of the distilling tower and thence into the wash. This result may be avoided by placing the rectifying column at the side of the distilling column (Fig. 15) instead of above it. This two-part apparatus, as it is called, produces a concentrated wash.

III. The Course of the Cooling Water.—The water first enters the spirit condenser *D* (Fig. 13) through the pipe *h*, and flows thence through *r* to the concentrator *C*, from which it escapes, as warm water, through the pipe *i*. For the purpose of cleaning the distilling apparatus water can be diverted through *m* to the top of the rectifying column and allowed to flow through both columns to *E*.

After long use, distilling apparatus occasionally acquires a crust, of a thickness up to ¾ inch, consisting of hardened mash, grease, sand, yeast cells, husks, etc. To remove this without taking the apparatus apart, it is filled with cold water. After a short interval the water is let off, all outlets are opened and a copper pan filled with equal parts of alcohol and kerosene is inserted from the side and set on one of the vapor-pipe caps. The mixture is then lighted. In three or four minutes the chamber becomes dry and hot and the crust so loose that it can be easily removed. The process is repeated with each chamber, beginning at the lowest. With a gallon of the mixture the largest apparatus can be cleaned in four hours.

b. The Ilges automatic one-part apparatus.

The Ilges apparatus is one of the best in regard to facility of operation and certainty of result, and it is therefore very extensively used. One of the earliest forms, dating from 1873, gave evidence of an attempt to increase the purity of the product by means of uniform and automatic working. For the same reason all operations—distillation, rectification, dephlegmation, even the removal of the wash—were performed as rapidly as possible, so that little time was given for the formation of decompositive products from impurities. Meanwhile the apparatus has been modified without abandoning the fundamental principle of its construction. All of Ilges's apparatus is entirely original. Fig. 16 illustrates the new one-part type, which is an improvement on the older and more commonly employed apparatus.

p is the mash reservoir, from which the mash is caused to flow with perfect uniformity by means of the mash regulator *G*, which works uninterruptedly. In the old apparatus it is necessary to interrupt the flow about once an hour for the purpose of adjusting the regulator. The mash regulator *G* is a balance, mounted on the hollow post *O*, which is connected below, by a curved pipe not shown in the illustration, with the bottom of the mash reservoir *p*. Below this curved pipe is a valve connected by a rod with the point *q* of the scale beam, so that the descent of the pan *r*, containing weights, tends to open the valve, and the descent of the pan *s* containing mash tends to close it. The level of the mash in *s* depends upon the amount of the counterpoise in *r* and if this level is higher than the overflow *t* the current of efflux remains constant, because the balance so adjusts itself, automatically, as to maintain a constant weight and therefore a constant depth of mash in *s*.

This uniform stream of mash flows through the apparatus *B* into the distilling column *A*. This column is of original construction, for it does not consist of many chambers, each containing a thin layer of mash, but is completely filled with mash and can consequently be made much smaller than the columns of other apparatus. In this column the mash flows over plates of peculiar form which give it a rapid reciprocating rotary motion. The arrangement of these plates is illustrated in Figs. 17 and 18. Each plate bears a number of ridges placed obliquely with respect to the corresponding radii. The spaces between these ridges form channels for the steam, and as the plates *a*, in which the ridges are inclined to the left, alternate with smaller plates *b*, in which the ridges are inclined to the right, the steam whirls the mash alternately in opposite directions, continually exposing a fresh surface, and thus effects very thorough distillation as the mash glides downward from plate to plate.

From the distilling tower the mash, now converted into wash, flows to the wash outlet and regulator *C*, which has a valve controlled by a float. The wash undergoes a continuous automatic test for alcohol and its vapor is condensed in the small condenser *c*. The handle *e* serves to test the adjustment of the valve and float.

The exhaust or live steam required for distillation is conducted to the distilling column through a regulator, which will be described presently.

From the distilling column the alcoholic vapor rises into the part *B*, the peculiar conformation of which compels the ascending vapor and the descending mash to flow side by side through long, narrow channels, and thus to exchange temperatures. Consequently *B* serves as a mash warmer, and, to some extent, as a dephlegmator.

The dephlegmator proper, *D*, is a square box containing horizontal tubes through which the cooling water flows, passing from one layer of tubes to the next through the water vessels attached to the sides of the box. These vessels are easily removed for the purpose of cleaning the tubes, and, being open at the top, permit the tubes to be reached with brushes while the apparatus is in operation. The vapor surrounds these tubes, and to increase the condensing surface the space between the tubes is filled with porcelain balls.

From the dephlegmator the vapor goes to the spirit condenser *E*, which is also open above and easily cleaned at all times, an advantage upon which Ilges lays great stress. This apparatus, as made for ordinary use, produces spirit of a fair degree of purity containing about 87 per cent by volume of alcohol. By enlarging the dephlegmator spirit of any desired strength up to 95 volume per cent can be obtained.

The Ilges steam regulator is illustrated in Fig. 19. Boiler steam entering through the plug *b* and exhaust steam entering through *d* pass on through the pipe *c* to the distilling column and at the same time exert a pressure, through the column *f*, upon the water in the vessel *h*, forcing it up through the pipe *g* to the upper vessel *i*. A large float in the upper vessel is connected by a lever with the valve *k*, which regulates the admission of steam. This valve (shown enlarged at the right) consists of a vertical cylinder within which a hollow piston is moved up and down by the float and lever. The interior of the cylinder communicates with the main steam pipe below it, and, according to its position, communication is made through orifices in its wall with the inlet for live steam, *b*, or the outlet for the superfluous steam, *c*, but never with both at once. The position of the valve has no effect on the exhaust steam, which flows without interruption from the plug *d*, through the main steam pipe, to *e*. When the supply of exhaust steam is exactly sufficient for the operation of the distilling apparatus the hollow piston *k*, governed by the float, assumes its mean position, in which both the inlet for live steam and the escape pipe are closed. Now, if the supply of waste or exhaust steam increases, the pressure in the column *f* also increases, forcing additional water into the upper vessel, raising the float and lowering the hollow piston until its interior is put into communication with the escape pipe *c*, through which the steam blows off, relieving the pressure. If, on the contrary, the supply of waste steam is too small, the pressure and the float fall and the piston rises until its interior communicates with the inlet *b*, through which live steam from the boiler flows to supply the deficiency.

The older regulator of Lavalle controlled the internal pressure only and was adapted only to apparatus in which steam, though admitted to the distilling column, was not the chief source of heat, nor could it regulate the admission of live and exhaust steam simultaneously.

A water regulator is added to the Ilges automatic apparatus if the water pressure is not constant.

In this way the regular and uniform operation of every part is automatically assured and the apparatus needs little attention.

c. Christoph's automatic apparatus.

This is similar in principle to Lavalle's apparatus, the chambered distilling column of which it retains. The mash is heated, however, by being conducted first through the wash still and then through a wide tube which surrounds the central steam pipe and empties into the uppermost chamber of the distilling column.

The rectifying column contains, instead of Lavalle's

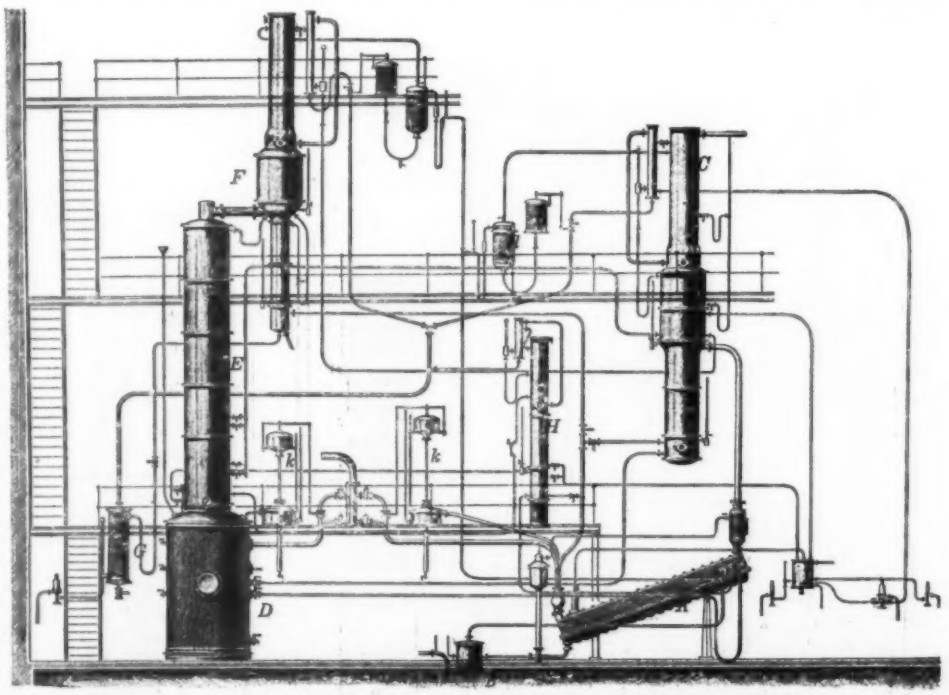


FIG. 25.—GUILLAUME DISTILLING AND RECTIFYING APPARATUS.

sieve-like plates, a series of floors of corrugated iron, the depressions of each floor being directly over the elevations of the next below. In these depressions are narrow slits through which the liquid from the concentrator falls on the elevations of the floor below, thus exposing the greatest possible surface to the action of the ascending vapor. From the rectifying column the

vapor goes to a dephlegmator and a concentrator. A strength of 96 or 96.5 per cent of alcohol is claimed for the spirit produced by this apparatus.

A mechanical regulator driven by steam regulates the flow of mash.

d. Pampe's low-pressure automatic apparatus, for continuous distillation.

This apparatus is constructed with one column for the production of spirit of about 90 per cent, and with two columns for spirit of 96 per cent. The latter form is provided with devices for the separation of the "foreshots" or aldehyde, and the "feints" or fusel oil, and is constructed for automatic operation. The special peculiarity of the apparatus is that the steam, or vapor, is opposed in the distilling column by a very low hydrostatic pressure, equivalent to only 40 inches of water at the point of entrance, and by no pressure whatever in the rectifying tower. This fact alone, according to the inventor of the apparatus, suffices to explain its production of refined spirit suitable for use as a beverage without further treatment, together with 5 or 10 per cent of a strong spirit containing aldehyde, which is well adapted for burning. The low pressure also saves fuel, as exhaust or waste steam can be used.

The apparatus (Fig. 20) comprises the distilling column *A*, the rectifying column *B*, the dephlegmator and mash warmer *C*, the aldehyde separator *D*, the double condenser *E*, the fusel oil separator *F*, the slop regulator *G*, the testing condenser *H*, the steam regulator *J*, the exhaust steam collector *K*, and the steam mash pump *P*.

The upper part of the distilling column contains a series of incomplete partitions with indented edges which cause the mash to meet the rising steam as a spray. Below are ten chambers, each containing a layer of mash less than half an inch thick.

The effiux of the spent wash is regulated automatically by a float valve. The rectifying column is similar in construction to the upper part of the distilling tower. The "low wine" is discharged automatically and its vapor and that of the spent wash are automatically tested for alcohol in the testing condenser *H*, which has two worms. The dephlegmator *C* consists of two concentric cylinders between which the mash pipe is coiled spirally. The mash is pumped to the top of this pipe, the lower end of which crosses over to the distilling column. Water flowing down the inside of the small and the outside of the large cylinder assists in the dephlegmation of the vapor which streams upward about the mash pipe. The water, cold at entrance, is discharged at 17 deg. F. Its quantity is three-fifths that of the mash if the latter contains from 3 to 8 volume per cent of alcohol and 96 volume per cent spirit is produced. For weaker spirit still less water is required.

The aldehyde or "foreshots" separator *D* contains horizontal perforated plates traversed by tubes down the inner surface of which water flows in thin sheets. The vapor enters the separator at the bottom and is condensed chiefly at the top. The liquid, falling through the vapor and the perforated plates in fine drops, flows from the bottom of the separator, through one division of the double condenser *E*, to the spirit reservoir. The uncondensed vapors and gases go through a separate pipe to the second division of the condenser, where they are condensed to a liquid containing a large proportion of aldehyde which is suitable for burning. The "feints" containing the fusel oil are separated in *F* from the "low wine" flowing from the upper part of the rectifying column. The steam regulator, of the flexible plate or "membrane" type, admits live steam when the pressure of the exhaust steam falls, while the steam chest *K* serves to diminish the shock to the membrane caused by the intermittence of the flow of exhaust steam.

Large apparatus of this model has an automatic water regulator and a steam mash pump with automatic regulation.

e. Automatic distilling and rectifying apparatus.

I. The Ilges apparatus for the production of refined spirit directly from mash of any sort, or from crude spirit, with continuous separation of all of the fusel oil and aldehyde.

All the types of apparatus hitherto described produce crude spirit containing more or less impurity. In view of the increasing demand for crude spirit they are still useful, as they are comparatively simple, work economically, and produce spirit of high proof.

Pure spirit was formerly obtained by submitting crude spirit to a further rectifying or refining process, but in recent years various types of apparatus have been introduced which produce and refine spirit in one operation.

Before 1890 Ilges had converted his one-part automaton into an apparatus for the production of pure spirit directly from mash. His latest and most elaborate apparatus, conducted on the same general principles but containing important improvements, is illustrated in Fig. 21. His cardinal principle, already referred to, is the performance of all operations, including the removal of the wash and "low wine," as rapidly as possible, in order to give no time for decomposition. In irregularly working apparatus the impurity of the product increases with the degree of irregularity and the time and opportunity afforded for chemical changes. The next step was to provide for continuous elimination of the impurities due to secondary fermentations and already present in the mash, the slightly volatile fusel oils (the chief impurities of the "feints") and the very volatile aldehydes and ethers of the "foreshots."

The improved apparatus delivers, in continuous streams, three liquids.

1. Ninety per cent of the alcohol of the mash in the form of absolutely pure spirit containing 96 to 96.5 per cent of alcohol by volume.

2. All the fusel oil in a concentration of 80 per cent.

3. All the "foreshots" in a strength exceeding 97 per cent.

The character of the raw material—thick potato mash, molasses wort, grain wort, or crude spirit—does not affect the operation or the result. Consequently the apparatus can be profitably employed in rectifying crude spirit in the intervals between distilling seasons, and can be kept in operation, day and night, throughout the year. The rectification of crude spirit requires less than one-fourth of the time occupied in producing an equivalent quantity of pure spirit from mash. The only change required is the substitution of the crude spirit regulator for the mash regulator, and the description applies throughout, if "crude spirit" is substituted for "mash."

The mash flows from its tank into the cylinder *H* of the mash regulator, whence it flows, governed by the automatic adjustment of the balance, through the valve 1 into the pan 2, thence through the funnel 3 and hollow globe 4 into the distilling column. If crude spirit is the raw material, it flows from its regulator through the mixing vessel *i* into the globe 4.

The distilling column is the same as that of Ilges's one-part automatic apparatus. The steam enters through the regulator *F F* and the plug *d*. The slop, entirely freed from alcohol, passes through the pipe 5 to the wash regulator, from which, controlled by a valve governed by a float, it issues in a uniform stream, which is continuously tested by an alcoholometer that reveals the slightest trace of alcohol.

The alcoholic vapor, still containing all of the light and heavy impurities, passes from the distilling column through the pipe *a* and the plug 6 to the first rectifying column, of which the function is to condense all of the fusel oil and eliminate it with the "low wine" and to raise the alcoholic strength of the vapor to 96.5 per cent by volume.

The bottom compartment, *K*, is an empty space in which the vapor mixes with vapor distilled separately from the "low wine" and arriving through plug 7. The top compartment *l* is an Ilges dephlegmator with horizontal tubes and porcelain balls. The intermediate compartments are separated only by horizontal gratings and are completely filled with porcelain balls. Contact with these balls, which are constantly wet with "low wine" from the dephlegmator *l*, has a powerful rectifying effect on the ascending vapor and all of its fusel oil is carried off with the "low wine" through the pipe *f*, past the thermometer *i* to the "low wine" cooler and thence through pipe 12 to the oil separator. Here the fusel oil, which is lighter than the watery "low wine" and insoluble in it when cold, rises to the top and flows, in a very concentrated state, through the bent pipe 10 to the fusel oil tank 11. The "low wine," thus freed from fusel oil, flows through pipe 14 to the "low wine" distilling column, where all of its alcohol is distilled off by steam entering at *d*. The alcoholic vapor goes to plug 7 of the first rectifying column and the residual "low wine" to an apparatus by which it is continually tested for traces of alcohol.

The main stream of vapor after losing its fusel oil in the first rectifying column passes through tube *b*, with an alcoholic strength of 96.5 per cent by volume, to the second rectifying column, where it is freed of aldehyde. Compartments *p* and *q* of the second rectifying column are dephlegmators similar to compartment *l* of the first rectifying column. Compartments *r* and *s*, called superheaters, are of similar construction but contain no balls, and superheated steam, instead of cold water, flows through their tubes. The remaining compartments, like those of the first column, are separated by gratings and packed with porcelain balls. The vapor, entering through pipe 6 and plug 21, ascends through *r* and the compartments above it, continually becoming stronger in aldehydes. Seven-tenths of the vapor is condensed and retained, as a low wine comparatively weak in aldehydes, in the dephlegmator *p*, two-tenths is condensed to a low wine strong in aldehydes in the upper dephlegmator *q*, while the remaining one-tenth passes as vapor through tube *c* to the "foreshots" condenser, carrying with it, in each minute, exactly as much aldehyde as the whole stream of vapor brings to the column in the same interval.

The lower part of the second rectifying column remains to be described. The vapor which enters at 21 in compartment *r* still contains all the aldehyde of the mash, and therefore is not in condition to free the descending low wine from aldehyde so completely that it can be drawn off at 17 as pure refined spirit. Therefore the vapor is superheated in *r* in order to increase its power to expel aldehyde from the spirit which, in consequence, is very nearly pure when it reaches plate 17. Still, however, it is not drawn off, but is conducted around the superheater *r*, by the pipe 22 to plate 20, whence it trickles among the balls of the compartments below down to plate 18, and then flows around the lower superheater *s*, through pipe 23, to the bottom compartment *t*. Here the spirit, which is now perfectly purified, flows over hot plates which vaporize part of it. The remainder flows through pipe *h* to the spirit cooler, and thence through pipe 24 to the outlet *R*. The vapor evolved from the pure spirit is superheated in *s* and then ascends through the lower compartments to remove the last traces of aldehyde from the descending liquid spirit.

The proportion of "foreshots" which must be separated in order to eliminate all of the aldehyde varies with the nature of the mash, but never exceeds 10 per cent of the total output of spirit. The "foreshots" have a strength of 97 volume per cent and may be denatured at once or passed again through the apparatus at a convenient time to extract the greater part of their alcohol in the form of pure spirit. The fusel oil may be advantageously employed in lighting the distillery.

It is evident from this description that the separation of "foreshots," fusel oil, and pure spirit is effected by simple means. No chemical or other process requiring constant attention is employed, and, despite the apparent complexity of the apparatus, everything is regulated automatically and is always under easy control. The thermometer of the low-wine pipe *f* indicates whether the whole operation is going on properly or not. The apparatus is too costly for small distilleries, but may be installed with great advantage by establishments distilling daily upward of 1,200 gallons of mash.

II. The Guillaume system of continuous distillation and rectification.

A peculiarity of the Guillaume system is the inclined distilling column (*A*, Figs. 22 to 25). This is made of cast iron or copper, is designed specially for concentrated grain and potato mash, and, according to its inventor, never becomes clogged. Along the floor runs a continuous groove down which the mash flows to the wash regulator *B* at the lower end. The steam enters at 2 and passes from chamber to chamber under the partitions 3, etc., to the highest chamber, 4, and the reservoir 5, when the crude alcoholic vapor goes to the mash warmer *B* or to a special concentrating column according as low-proof or high-proof spirit is desired. The inclined column consists of two parts—the floor and the distilling capsules above it. By removing the short inclined screws of the flange *C* (Fig. 24) the bottom can be lowered on the long vertical bolts *a* and the interior of the column exposed. The flow of steam is controlled by an automatic Lavalle regulator. The wash, regulated by a float valve, flows through the mash warmer.

The crude spirit vapor goes from the top of the distilling column to the middle of the first rectifying column *C* (Fig. 25), through which it rises to the dephlegmator above. Here the spirit is condensed and the aldehydes separated in the pure state.

The liquid spirit, thus freed from aldehyde, goes to the accumulator *D*. According to Guillaume every variation in heating, condensation, feed, or discharge of products interferes with the requisite uniformity of distribution among the chambers and consequently with the uniformity of the product. Such variations may also cause a loss of alcohol in the wash. For example, when alcohol is discharged less rapidly than it is brought in with the mash the column becomes overcharged, and as the alcoholic strength in the highest chambers cannot be greatly increased, the overcharge must be taken up by the chambers near the feed pipe and below it and ultimately go into the wash. On the other hand, if alcohol is delivered faster than it is supplied, the contents of the chambers and the strength of the spirit produced will gradually diminish.

These evils are abated by the accumulator, which always contains a large quantity of spirit. The vapor rises as required into the main rectifying column *E* and any excess can be diverted into the distilling column.

In the main rectifying column the spirit is freed from fusel oil and other "feints," which escape through the small condenser *i*. The alcoholic vapor, strong and almost pure, then undergoes a final rectification in a fourth column *F*, whence it passes to the spirit condenser *G*.

In the oil concentrator *H* the fusel oil is separated from the alcohol which accompanies it and the latter is returned to the distilling apparatus.

The Guillaume apparatus is constructed of any desired capacity. Sets are now in operation which produce in twenty-four hours more than 5,000 gallons of refined spirit, obtaining about 90 per cent of the alcohol of potato mash in that form together with by-products of high and uniform strength, which are salable without further rectification.

BRIDGING OF THE YALU.

THE papers from Japan discuss the proposal to build a bridge over the Yalu from Siu-Wiju (New Wiju) to Yongampho. New Wiju is ten miles down stream from the original Wiju, and lies near Antung. The roadbed will be 40 feet above the water, and the length of the bridge will be 3,239 feet. There will be embankments some 300 feet long on each side of the river, but the engineering difficulties are not thought to be serious. The cost is estimated at two million yen. The bridge will be used chiefly for railway purposes, but there will also be a road for general traffic, which, however, will be so arranged that it can at any time be converted into the bed of an additional railway track. Junks will be able to pass under the bridge merely by lowering one section of their mainmasts. It is expected that the bridge will be ready for use in 1909, which is about the time when the conversion of the Wiju-Mukden line will be completed. Travelers will then be able to reach Mukden from Fusan (the port in the south of Korea) without alighting from the train. It will be remembered that a short time ago we described a journey between the two capitals, Tokio and Seoul, entirely by railway, except the short sea passage between Shimonoseki and Fusan. When the railway is completed between Seoul and Antung, and the bridge which we have mentioned built over the

Yalu, the journey from Tokio to Mukden will be made very quickly. This railway will be of immense advantage to Japan from a commercial point of view, as it makes available all the resources of Korea and Manchuria, and for industrial purposes makes them part of Japan. Raw materials can be brought from them more cheaply than from the northern parts of Japan to the manufacturing centers, and they open up immense fields for the manufactured products of Japan. No doubt the people who are oppressed by the nightmare of a renewed conflict between Japan and Russia see in this railway an increased cause of uneasiness, but it is to be hoped that it will only be used for commercial purposes. The East China Railway is useless, to each power alike, for purposes of military transport. Neither could employ it without such a violation of the Portsmouth treaty as would amount to an act of war. The Japanese papers assure us that there is no reason whatever to suspect Japan of ambitious designs in northern Manchuria, and that if ever there be a war of revenge, the incentive will not come from Japan's side. At the same time they point out that the best way to avert such a catastrophe is to be amply provided against it, and the Fusan-Mukden line will add immensely to the offensive and defensive strength of Japan.—Engineering.

TRADE NOTES AND FORMULÆ.

To Remove the Smell of Wood and Mold.—The surfaces of the boxes, wooden vessels, etc., affected should be coated with the following mixture: 100 parts of acetic ether, 6 parts of formaldehyde solution, 4 parts of phenol, and 60 parts of tincture of eucalyptus leaves. The boxes to be then exposed in the open air to the sun.—Neueste Erfindungen und Erfahrungen.

To Prepare Syndeticon.—The following is said to be the best recipe for making this adhesive material: Dissolve 10 parts of sugar in 30 parts of distilled water; add 2.6 parts of slaked lime and allow to stand for three days at a temperature of 70 to 75 deg. C., shaking the mixture up frequently. After it has settled, dissolve 30 parts of glue in 20 parts of the sugar solution and heat for about 10 hours in a closed boiler. The evaporated water must of course be replaced and the alkalinity of the glue neutralized with oxalic acid. A solution of strong carbolic acid may be used as a preservative and oxalic acid (90 per cent) as a diluent.

Marking Ink With Base of Aniline Hydrochlorate.—Aniline hydrochlorate is a colorless salt possessing a strong affinity for water and forming deep black compounds with various metallic, and especially with copper, salts. Two liquids are therefore required in preparing the above ink; they should be mixed shortly before use and applied immediately, as the black or dark gray deposit is quickly precipitated. The aniline salt mixture may also be applied first and the developing fluid immediately afterward; some difficulty may, however, arise on account of the necessity of both applications exactly coinciding, but the signs thus obtained are more lasting.

(*a*) 1. 10.34 parts by weight of cupric chloride,
6.89 parts by weight of sal-ammoniac,
13.72 parts by weight of sodium chlorate,
68.95 parts by weight of distilled water,

2. 16.40 parts by weight of aniline hydrochlorate,
13.00 parts by weight of gum arabic,
3.40 parts by weight of glycerine,
33.00 parts by weight of distilled water.

Both liquids must be mixed shortly before use in the proportion of 1 : 1 and immediately applied.

(*b*) 1. 2.38 parts by weight of cupric chloride,
95.23 parts by weight of spirit of sal-ammoniac,
2.38 parts by weight of sodium chloride (common salt),

2. 94.28 parts by weight of aniline hyrochlorate,
35.28 parts by weight of gum arabic,
35.28 parts by weight of glycerine,
35.29 parts by weight of distilled water.

The liquids to be mixed before use in the proportion of 4 parts of the first to 1 part of the second.

(*c*) 1. 10.00 parts by weight of cupric chloride,
12.60 parts by weight of sodium chlorate,
6.30 parts by weight of sal ammoniac,
71.10 parts by weight of distilled water.

2. 24.60 parts by weight of aniline hyrochlorate in 36 parts of distilled water,
1.25 parts by weight of gum arabic,
13.65 parts by weight of glycerine,
24.60 parts by weight of distilled water.

Marking Ink for Linen.

30.00 parts by weight of manganese phosphate,
60.00 parts by weight of hydrochloric acid,
15.00 parts by weight of anthracene,
7.5 parts by weight of potassium chromate,
Gum arabic as required,
7.5 parts by weight of water.

Dissolve the manganous phosphate in the hydrochloric acid, add the anthracene with the potassium chromate and water, shake well after further adding a small quantity of gum arabic and keep in well stoppered bottles.

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